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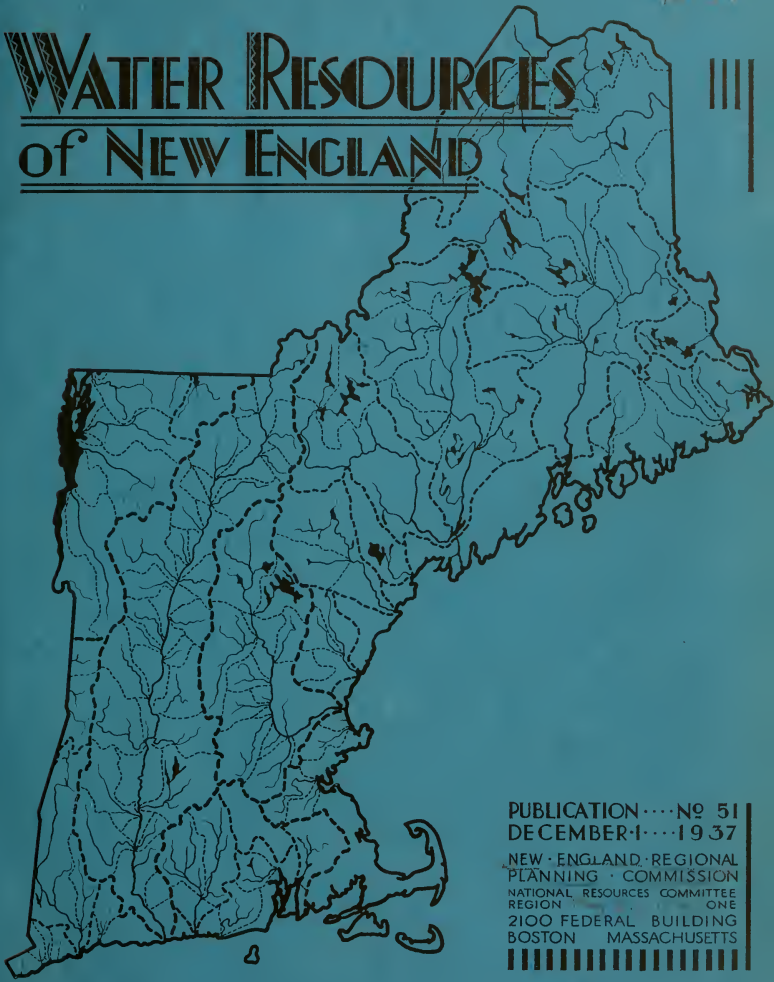
WATER RESOURCES of NEW ENGLAND



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NEW·ENGLAND·REGIONAL
PLANNING · COMMISSION
NATIONAL RESOURCES COMMITTEE
REGION ONE
2100 FEDERAL BUILDING
BOSTON MASSACHUSETTS

MAP Nº 1

NOTE

AREAS WITHOUT CONTOURS IN MAINE NEW HAMPSHIRE AND VERMONT ARE AREAS FOR WHICH FINAL SHEETS HAD NOT BEEN ISSUED BY THE U.S. GEOLOGICAL SURVEY UP TO AUGUST 1937.

NEW ENGLAND WATER RESOURCES

TOPOGRAPHY

JUNE 30 1937

Legend

200 FOOT CONTOURS

PRINCIPAL RIVERS IN GENERAL RIVERS SHOWN DRAIN AT LEAST 100 SQUARE MILES.

PRINCIPAL WATERSHEDS

SCALE

0 10 20 30 40 50 MILES

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

WATER RESOURCES OF NEW ENGLAND

Drainage Basin Data and Problems

NEW ENGLAND REGIONAL PLANNING COMMISSION

December 1, 1937

Prepared by the Drainage Basin Committees
for Maine and for Central New England

with the cooperation of

National Resources Committee, Region One
2100 Federal Building, Boston, Massachusetts

Mimeographed by

National Resources Committee, Region One
Boston, Massachusetts

June 1, 1938

NATIONAL RESOURCES COMMITTEE
FIELD OFFICE
2100 Federal Building
Boston, Massachusetts

June 30, 1938

Hon. Harold L. Ickes
Chairman, National Resources Committee
North Interior Building
Washington, D. C.

Dear Sir,

As Chairman of the New England Regional Planning Commission and of the Maine and Central New England Drainage Basin Committees, I have the honor to transmit to you herewith our Report - WATER RESOURCES of NEW ENGLAND.

I commend this Report to your especial attention because it is not merely a revision of the Water Resources Report (New England section) of December, 1936 - it is more than that. Not only is the material of the 1936 Report brought up to date, but during the calendar year of 1937 careful research was continued and data never before available in printed form has been compiled. The present Report can safely be said to be the nearest to a complete appraisal of the water resources of New England that has ever been given to the public.

We have been fortunate in having on our staff during the period of gathering, analysing and compiling data several technicians whose ability as experts in the various water problems has made for accuracy and comprehensiveness in the manuscript. Following the compilation of the report, it was submitted for criticism by the members of the Drainage Basin Committees, the members of the New England Regional Planning Commission, and various experts of State and Federal Departments. Their criticisms were then incorporated in this final version.

The highest use we can wish to be made of our Report is that it shall serve as a reliable source of information and guidance for whatever agencies may share in the duty of developing to the best advantage the WATER RESOURCES of NEW ENGLAND.

Very truly yours,

Victor M. Cutter
Chairman

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INTRODUCTION

Study of the Water Resources of New England is an important phase in the formulation of a Regional Plan for this great area involving six states -- covering more than sixty thousand square miles.

The Basic Regional Plan for New England includes:

1. A plan for a coordinated system of all forms of transportation;
2. A plan for the conservation and development of water resources;
3. A program for land utilization according to modern methods and practices;
4. A program for conservation of forests and wildlife;
5. A program for development of recreational facilities, including, among others, interstate reservations, parkways, foot and bridle trails;
6. A draft of the legislation necessary to effective execution of the plans formulated;
7. Economic, social, and related studies dealing with such subjects, like population, industry, and housing, as are essential to the formulation of the basic Regional Plan.

Three of the most important river systems of New England -- the Connecticut, Merrimack and Blackstone -- have in their drainage basins more than 31.2% of the population of the region, 30.4% of the manufacturing, and a large percentage of the productive agricultural land. They constitute the source of 51.2% of the water power generated in New England. Through these same valleys are transported millions of dollars' worth of the products of agriculture and industry -- raw materials and finished goods -- on main line railroads and highways. The bottom lands of the major streams in the region are at once those areas through which the very lifeblood of the region flows, and in which the very life of the region exists. Water is basically essential to life. Being precious, its use should be understood and conserved so that it will be of the highest benefit to those whom it serves. The flow of water knows no political boundaries, no state lines. Those who live and work on the lower reaches of a great river basin are entitled to the use of the normal flow of the water unimpaired as to quantity and quality. There is no special right of a people on the upper reaches of a river to pollute the water that is to flow past the people on the banks below. Industry that uses water for processing has a right to have clean water for its purposes, and in turn has an obligation to return that water to the stream in fit condition for use by a neighbor industry downstream.

In this region where recreation and the allied industries that furnish accessories to recreation have assumed so great importance, the recreational values lying dormant in the great stream areas and on the ocean and lake shores of New England should be recognized and reclaimed. In the three major interstate stream valleys alone, a high degree of pollution has rendered great stretches of the rivers and their banks undesirable for human habitation, much less for any type of recreational use. In all the major valleys floods have cost hundreds of millions of dollars in property, soil, and time lost. The gradual control of these floods through construction of detention, flood control, water supply or power reservoirs on the upper reaches of the streams, through removal of channel obstructions, and through building of dykes and levees, and the control of erosion through intelligent planting and harvesting of timber and other crops, constitute a problem offering a CHALLENGE TO THE FORESIGHT OF THE NEW ENGLAND PEOPLE AND TO THEIR ABILITY TO COOPERATE ON MATTERS OF COMMON ECONOMIC AND SOCIAL INTEREST.

That the determination of the best social and economic uses of the water resources of New England is a regional problem is obvious; similarly, no plan for construction of reservoirs can be made that does not influence the location or relocation of some form of transportation service, some kind of property use in which there is an economic interest, -- farms, industries, dairies, or homes. The compact settlement of New England, plus the interrelation of the flow lines of industry, transportation, trade and recreation with the flow lines of water, increases the complexity of this regional problem.

Shortly after the formation of the New England Regional Planning Commission, the Chairman appointed a Water Resources Committee to indicate the basic information needed and to formulate the water policy of the Commission. This Committee (by way of cooperating with the P.W.A. state engineers) examined and classified Public Works projects relating to water resources; recommended a modified form of the bill submitted by Representative William M. Citron of Connecticut which provides for Federal enabling legislation to permit the forming of interstate compacts; drew up forms for interstate compacts for the development of water resources in the Connecticut, Merrimack and Blackstone Rivers basins; drafted a plan of procedure for conducting investigations in the Connecticut River valley. The Commission has prepared a bibliography of interstate water resources information, and has made it available to State health engineers and others concerned with water resources problems.

Long before the flood of 1936 the Commission had prepared River Basin Maps and studies and had assembled bibliographies of available material that had been compiled from time to time by many competent authorities on various phases of water problems.

Before the Commission made its studies of the Connecticut, Merrimack and Blackstone Valleys, only the Army Engineers had treated the problems of interstate streams as basin problems. The "308" Reports submitted to Congress by the Secretary of War were the only comprehensive studies of the major interstate streams in New England. However, the recommendations of these reports dealt only with flood control and navigation problems, and included only those potential developments of an interstate nature which the Army Engineers considered of sufficient importance to be carried out by the Federal Government.

Data and studies of basic importance have been assembled by the Geological Survey, the Weather Bureau, and by numerous private and semi-public agencies. This material has been digested and correlated, and with the cooperation of the Water Resources Committee a program for the assembly of needed information has been drafted. This same schedule has been of use in setting up, with the cooperation of the W.P.A., data-collecting projects in several states.

Floods causing fully $100,000,000 damage struck New England in March, 1936. The Commission, through news releases and public addresses by the Chairman and Consultant, immediately called public attention to the regional character of the control problem, and was ready with suggested forms for interstate compacts, as prepared by the Water Resources Committee of the New England Regional Planning Commission in August, 1935. By June, 1936 all four states on the Connecticut River had created agencies for the purpose of agreeing on a form of compact for the control of floods and the allocation of costs. On March 8, 1937 Secretary of War Woodring and General Markham, Chief of the Army Engineers, called the Governors of New Hampshire, Vermont, Massachusetts and Connecticut together at Hartford, Connecticut, and urged them to come to an early conclusion on an interstate agreement. On March 16 -- but eight days after the Hartford conference -- the compact committee* came to an agreement.

On July 6, 1937 representatives of New Hampshire, Vermont, Massachusetts and Connecticut met in the State House in Boston, signed the compacts for both the Connecticut and Merrimack Rivers and forwarded the same to Congress for ratification.

Resolutions for Congressional ratification were approved by the Commerce Committee of the Senate and by the Flood Control Committee of the House, but had not been acted upon by Congress up to December 1, 1937.

The New England Regional Planning Commission and its Water Resources Committee and Staff have, we believe, stimulated and aroused public interest in and understanding of the comprehensive and regional character of water problems in New England; have instigated the collection of existing and needed information on the subject; and have brought together, for a determination of

* See foot note on following page.

regional policy, the representatives of the several states at a stage early enough to have had an important effect on the dispatch with which interstate compacts were completed and ratified by the respective legislatures.

The making of a plan for the New England region is a long-term effort involving the collection and interpretation by competent authorities of a vast amount of data on all interrelated subjects and, what is even more important, involving the cooperation of local, state, and Federal agencies with private business, industrial, and transportation agencies.

The accomplishments of the New England Regional Planning Commission have been made possible by the cooperation of the several State Planning Boards through their Chairmen. By continuously studying the needs of the Region in the light of changing social and economic conditions, and by constantly balancing these needs in terms of a comprehensive plan, there has been prepared a long-term, yet flexible, plan for the Region. This process should be followed consistently and continually. Such a plan, with revision and approval by representatives of all the states, can record at any given time the best coordinated judgment of authorities on specific problems in many fields. Thus, there can always be a Plan for New England. The degree to which it is effective is the degree to which it is understood and the extent of the cooperation which is achieved in its constant interpretation and modification.

The following report on the Water Resources of New England is an important addition to the data on one phase of the New England Regional Plan. These data and the proposals contained in this report are being studied in connection with the data on and proposals for the solution of recreational, transportation, industrial, social and economic problems. Thus they contribute to the refinement and improvement of the PLAN FOR NEW ENGLAND.

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TABLE I.

SUMMARY OF PERTINENT INFORMATION

FOR NEW ENGLAND BY PRINCIPAL BASINS

	Maine Basins	Merrimack Basins	Massachusetts Coastal Basins	Narragansett-Eastern Conn.	Connecticut Basin	Housatonic-Hudson Basins	Western Vermont Basins	Total New England
Drainage area, square miles	33,785	5,015	2,000	3,580	11,205	3,295	4,875	63,755
Percentage of area in Farms (1935)	24	44	30	56	53	57	75	39
Percentage of area in Crops (1934)	7	10	7	12	12	14	22	10
Percentage of area in Woodland (estimate)	85	70	50	60	70	60	48	75
Estimated population, 1920	875,000	770,000	2,160,000	1,380,000	1,095,000	900,000	220,000	7,401,000
Estimated population, 1930	906,000	810,000	2,410,000	1,510,000	1,230,000	1,070,000	230,000	8,166,000
Population density, 1930, persons per sq.mi.	27	162	1,200	420	100	325	47	128
Number of cities or towns of over 10,000 pop.	15	16	40	27	20	23	3	144
Percentage of total population in these cities	34	69	90	78	62	83	23	72
Percentage of urban population (1930 census)	45	76	94.5	87	72	84	36	79
Percentage of rural population (1930 census)	55	24	5.5	13	28	16	64	21
Area of public recreation and conservation lands, sq.mi.	620	318	76	114	577	133	72	1,910
Percentage of total area	1.84	6.34	3.80	3.18	5.15	4.03	1.48	3.00
App. value of industrial products, 1929, millions of dollars.	440.	770.0	1,740.	1,280.	1,070.	1,050.	80.0	6,400
App. value of industrial products, 1933, millions of dollars.	250.	290.0	590.	555.	390.	440.	35.0	2,550
App. value of industrial products, 1935, millions of dollars (Rough estimate based on state total figures)	315.	490.	1,075.	795.	625.	640.	50.0	3,990

TABLE II

WATER SHEDS AND STREAM GAGING STATIONS

TO ACCOMPANY MAP #2

A MAINE BASINS

St. John R. Basin
1. St. John R., Fort Kent, Me.
2. Allagash R., Allagash, Me.
3. Fish R., Fort Kent, Me.
4. Aroostook R., Washburn, Me.

St. Croix R. Basin
5. St. Croix R., Vanceboro, Me.
6. St. Croix R., Baileyville, Me.
7. Grand Lake Stream, Grand Lake Stream, Me.

Machias R. Basin
8. Machias R., Whitneyville, Me.
9. E. Machias R., E. Machias, Me.

Union R. Basin
10. W.Branch Union R., Amherst, Me.

Penobscot R. Basin
11. W. Branch Penobscot R., Millinocket, Me.
12. W. Branch Penobscot R., Medway, Me.
13. Penobscot R., W. Enfield, Me.
14. E. Branch Penobscot R., Grindstone, Me.
15. Mattawamkeag R., Mattawamkeag, Me.
16. Piscataquis R., Foxcroft, Me.
17. Piscataquis R., Medford, Me.
18. Sebec R., Sebec, Me.
19. Pleasant R., Milo, Me.
20. Passadumkeag R., Lowell, Me.

Kennebec R. Basin
21. Moosehead L., east outlet, Me.
22. Kennebec R., Moosehead, Me.
23. Kennebec R., The Forks, Me.
24. Kennebec R., Bingham, Me.
25. Kennebec R., Waterville, Me.
26. Dead R., The Forks, Me.
27. Austin Stream, Bingham, Me.
28. Carrabassett R., N. Anson, Me.
29. Sandy R., Mercer, Me.
30. Sebasticook R., Pittsfield, Me.
31. Cobbosseecontee Stream, Gardiner, Me.

Androscoggin R. Basin
32. Androscoggin R., Gorham, N.H.
33. Androscoggin R., Rumford, Me.
34. Androscoggin R., Auburn, Me.
35. Magalloway R., Aziscohos Dam, Me.
36. Swift R., Roxbury, Me.
37. Little Androscoggin R., So. Paris, Me.

Presumpscot R. Basin
38. Presumpscot R., Sebago L., Me.

Saco R. Basin
39. Saco R., Conway, N.H.
40. Saco R., Cornish, Me.
41. Saco R., W. Buxton, Me.
42. Ossipee R., Cornish, Me.

Piscataqua R. Basin
43. Salmon Falls R., Lebanon, Me.

B MERRIMACK BASIN

1. East Br., Pemigewasset R. Lincoln, N.H.
2. Pemigewasset R., Plymouth, N.H.
3. Merrimack R., Franklin Jnc., N.H.
4. Merrimack R., Manchester, N.H.
5. Merrimack R., Lawrence, Mass.
6. Bakers R., Rumney, N.H.
7. Smith R., Bristol, N.H.
8. L. Winnipesaukee, Lakeport, N.H.
9. Contoocook R., Penacook, N.H.
10. N. Branch Contoocook R., Antrim, N.H.
11. Blackwater R.,Contoocook, N.H.
12. Suncook R., No. Chichester, N.H.
13. Souhegan R., Merrimack, N.H.
14. So. Branch Naghua R., Clinton, Mass.
15. Sudbury R., Framingham Cen., Mass.
16. L. Cochituate , Cochituate, Mass.

C MASSACHUSETTS COASTAL BASINS

Ipswich R. Basin
1. Ipswich R., Ipswich, Mass.

Charles R. Basin
2. Charles R., Waltham, Mass.
3. Mother Brook, Dedham, Mass.

D THAMES-BLACKSTONE-TAUNTON BASINS

Taunton R. Basin
1. Taunton R. State Farm. Mass.
2. Wading R., Norton, Mass.

Blackstone R. Basin
3. Blackstone R., Worcester, Mass.
4. Blackstone R., Woonsocket, R. I.

Thames R. Basin
5. Willimantic R., So. Coventry, Conn.
6. Shetucket R., Willimantic, Conn.
7. Hop R., Columbia, Conn.
8. Natchaug R., Willimantic, Conn.
9. Quinebaug R., Quinebaug, Conn.
10. Quinebaug R., Putnam, Conn.
11. Quinebaug R., Jewett City, Conn.
12. Moosup R., Moosup, Conn.
13. Yantic R., Yantic, Conn.

E CONNECTICUT BASIN

1. Conn. R., No.Stratford, N.H.
2. Conn. R., Waterford, Vt.
3. Conn. R., So.Newbury, Vt.
4. Conn. R., White Riv. Junc., Vt.
5. Conn. R., Turners Falls, Mass.
6. Conn. R., Montague City, Mass.
7. Conn. R., Thompsonville, Conn.
8. Passumpsic R., Passumpsic, Vt.
9. Moose R., St. Johnsbury, Vt.
10. White R., Bethel, Vt.
11. White R., W. Hartford, Vt.
12. Mascoma R., Mascoma, N. H.
13. Ottauquechee R., No. Hartland,Vt.
14. Sugar R., W.Claremont, N. H.
15. Black R., N.Springfield, Vt.
16. West R., Newfane, Vt.
17. Ashuelot R., Gilsum, N. H.
18. Ashuelot R., Hinsdale, N. H.
19. Otter Brook, Keene, N. H.
20. So. Branch Ashuelot R., Webb, N. H.
21. Millers River, Winchendon, Mass.
22. Millers R., Erving, Mass.
23. Sip Pond Brook, Winchendon, Mass.
24. Priest Brook, Winchendon, Mass.
25. E. Branch, Tully R., Athol, Mass.
26. Moss Brook, Wendell Depot, Mass.
27. Deerfield R., Charlemont, Mass.
28. Ware R., Cold Brook, Mass.
29. Ware R., Gibbs Crossing, Mass.
30. Chicopee R., Birchan Bend, Mass.
31. Swift R., West Ware, Mass.
32. Quaboag R., W. Brimfield, Mass.
33. Westfield R., Knightville, Mass.
34. Westfield R., Westfield, Mass.
35. Middle Br., Westfield R., Goss Heights, Mass.
36. Westfield Little R.,Westfield, Mass.
37. Scantic R., Broad Brook, Conn.
38. Farmington R., New Boston, Mass.
39. Farmington R., Riverton, Conn.
40. Farmington R., Tariffville, Conn.
41. Burlington Br.,Burlington, Conn.
42. Hockanum R., E. Hartford, Conn.
43. Salmon R., E. Hampton, Conn.

F HOUSATONIC-HUDSON BASINS

Quinnipiac R. Basin
1. Quinnipiac R.,Wallingford, Conn.

Housatonic R. Basin
2. Housatonic R., Gr.Barrington, Mass.
3. Housatonic R., Falls Village, Conn.
4. Housatonic R., Stevenson, Conn.
5. Ten Mile R., Gaylordsville, Conn.
6. Still R., Lanesville, Conn.
7. Sherpag R., Roxbury, Conn.
8. Pomperaug R., Southbury, Conn.
9. Naugatuck R., Thomaston, Conn.
10. Naugatuck R., Naugatuck, Conn.
11. Leadmine Br., Thomaston, Conn.

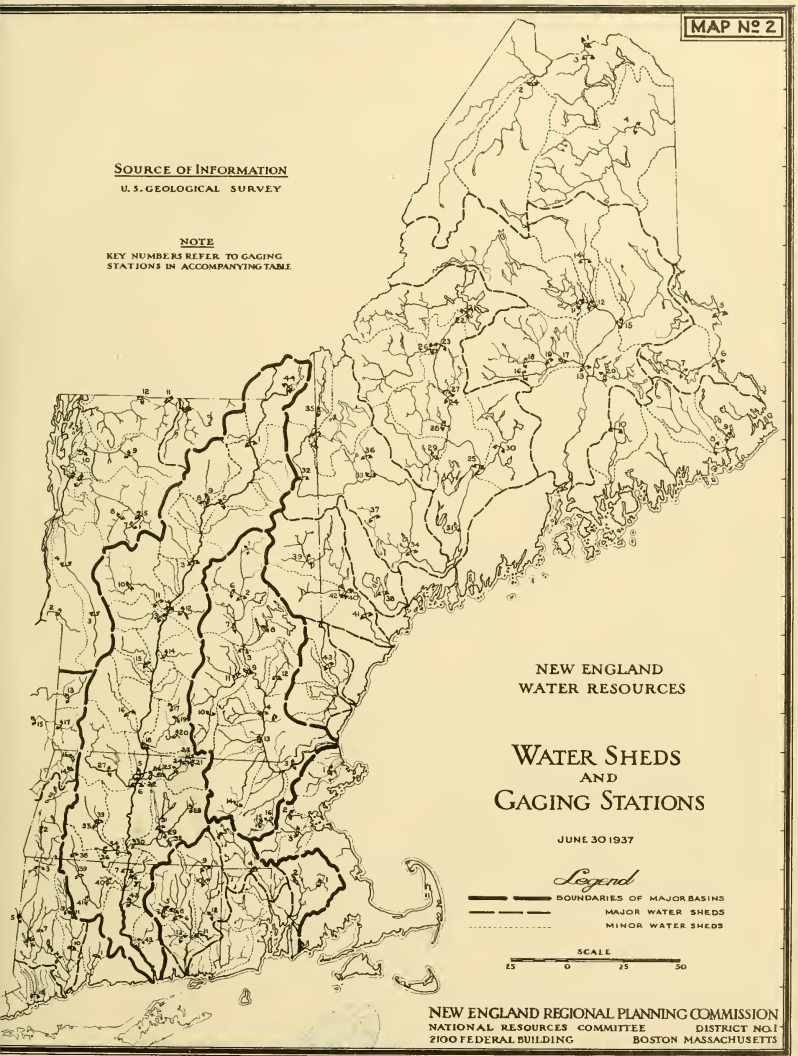
Saugatuck R. Basin
12. Saugatuck R., Westport, Conn.

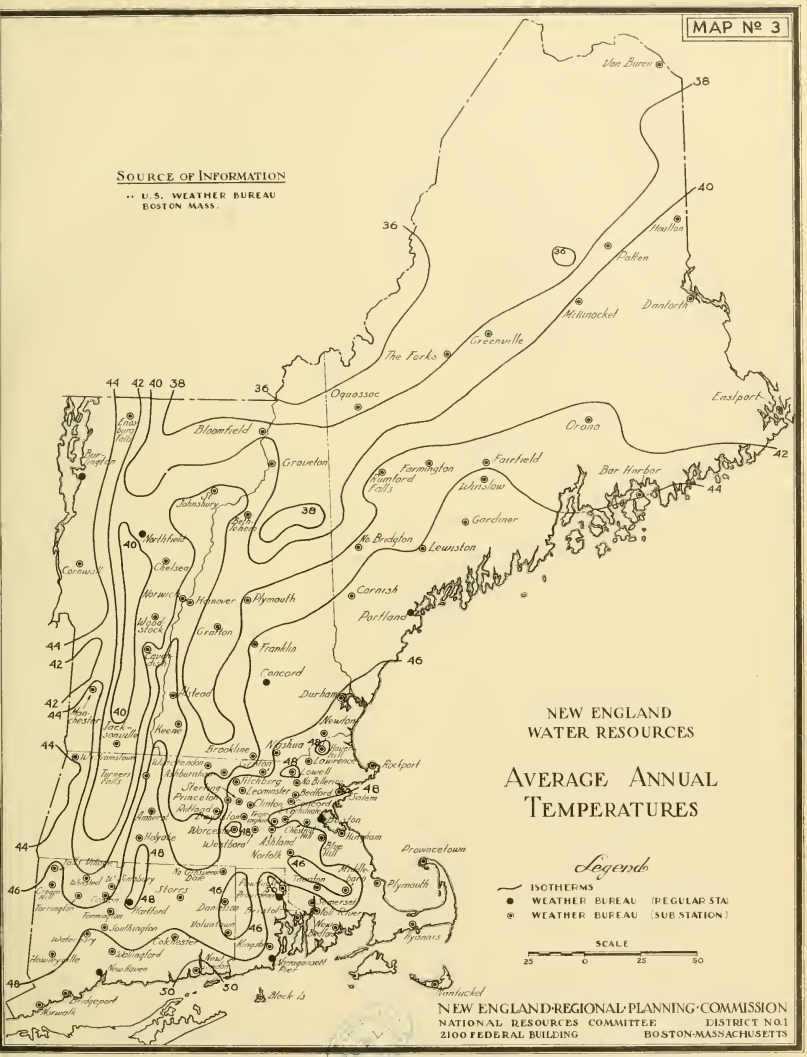
Hudson R. Basin
13. Batten Kill at Arlington, Vt.
14. Hoosic R., Adams, Mass.
15. Hoosic R., Eagle Bridge, N. Y.
16. N. Branch Hoosic R., N.Adams, Mass.
17. Walloomsac R., N.Bennington, Vt.

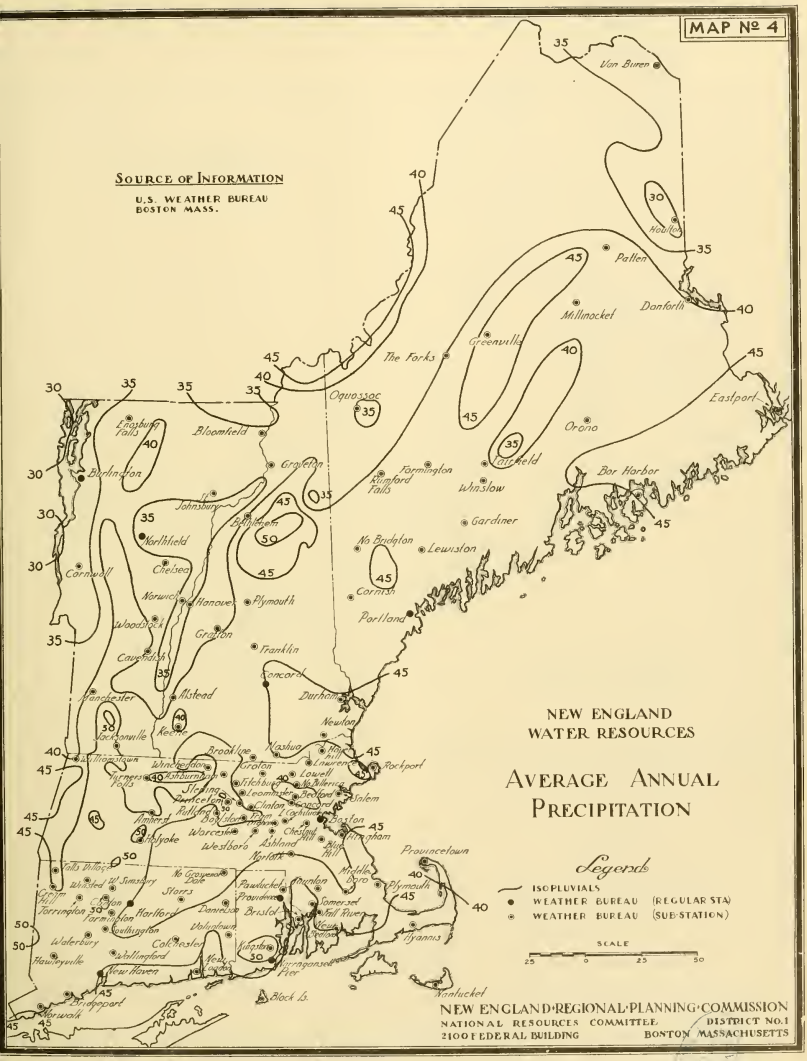
G CHAMPLAIN BASIN

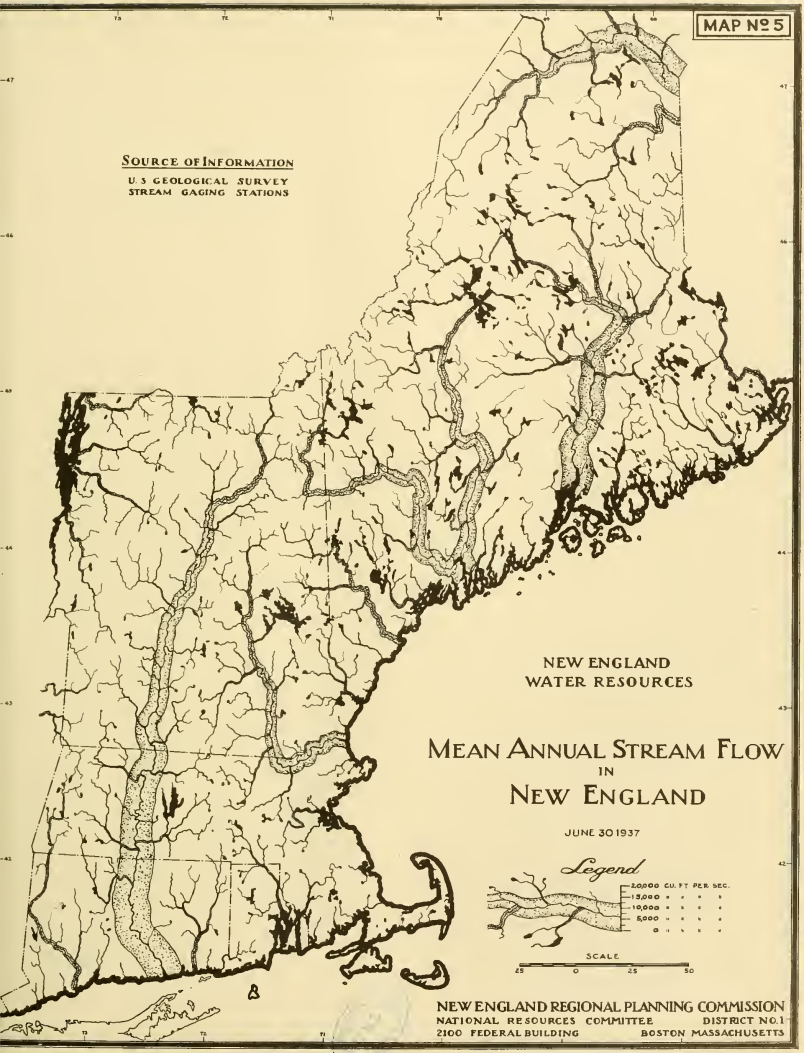
Tributary to St. Lawrence R.
1. L. Champlain, Burlington, Vt.
2. Poultney R., Fair Haven, Vt.
3. Otter Creek, Center Rutland, Vt.
4. Otter Creek, Middlebury, Vt.
5. Winooski R., Montpelier, Vt.
6. Winooski R., Essex Junction, Vt.
7. Dog R., Northfield, Vt.
8. Mad R., Moretown,Vt.
9. Lamoille R., Johnson, Vt.
10. Lamoille R., Milton, Vt.
11. Missisquoi R., No.Troy, Vt.
12. Missisquoi R., Richford, Vt.
13. Lake Memphremagog, Newport, Vt.
14. Clyde R., Newport, Vt.

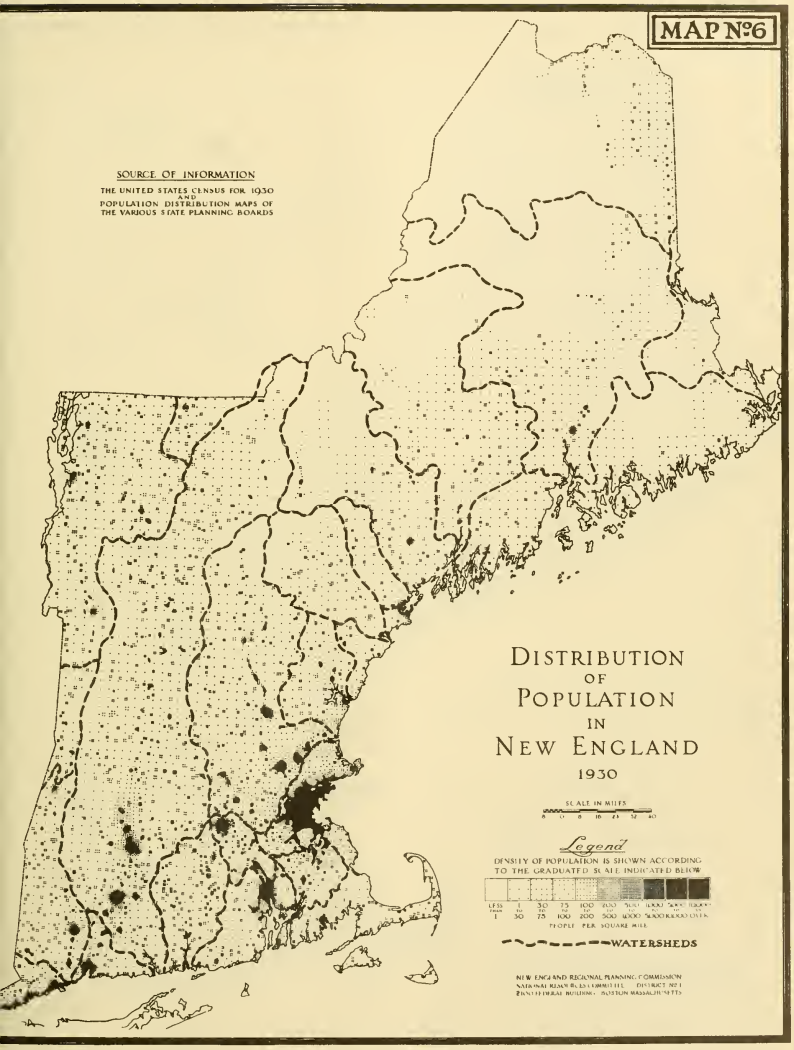
MAP Nº 2

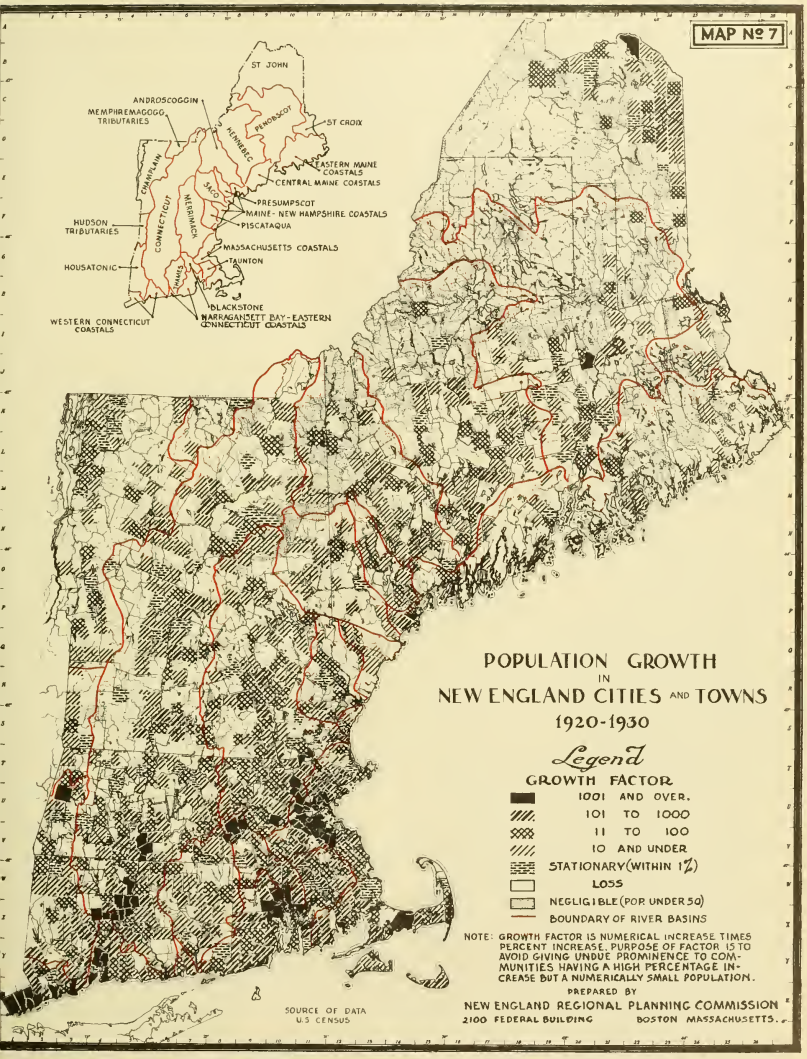

SOURCE OF INFORMATION
U. S. GEOLOGICAL SURVEY
NOTE
KEY NUMBERS REFER TO GAGING STATIONS IN ACCOMPANYING TABLE
NEW ENGLAND
WATER RESOURCES
WATER SHEDS
AND
GAGING STATIONS
JUNE 30 1937
Legend
BOUNDARIES OF MAJOR BASINS
MAJOR WATER SHEDS
MINOR WATER SHEDS
SCALE
25 0 25 50
NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT NO. 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS


MAP Nº 3
SOURCE OF INFORMATION
.. U.S. WEATHER BUREAU
BOSTON MASS.
NEW ENGLAND
WATER RESOURCES
AVERAGE ANNUAL
TEMPERATURES
Legend
ISOTHERMS
WEATHER BUREAU (REGULAR STA)
WEATHER BUREAU (SUB STATION)
SCALE
25 0 25 50
Van Buren
Houlton
Presque Isle
Millinocket
Dover-Foxcroft
Greenville
The Forks
Oquossoc
Eastport
Orono
Bloomfield
Farmington
Fairfield
Bar Harbor
Rumford Falls
Johnsbury
Waterville
Gardiner
No. Bridgton
Lewiston
Portland
Cornish
Plymouth
Franklin
Concord
Durham
Newton
Nashua
Lowell
Lawrence
Rockport
Salem
Boston
Provincetown
Plymouth
Hyannis
Nantucket
Block Is.
NEW ENGLAND-REGIONAL-PLANNING-COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT NO.1
2100 FEDERAL BUILDING BOSTON-MASSACHUSETTS

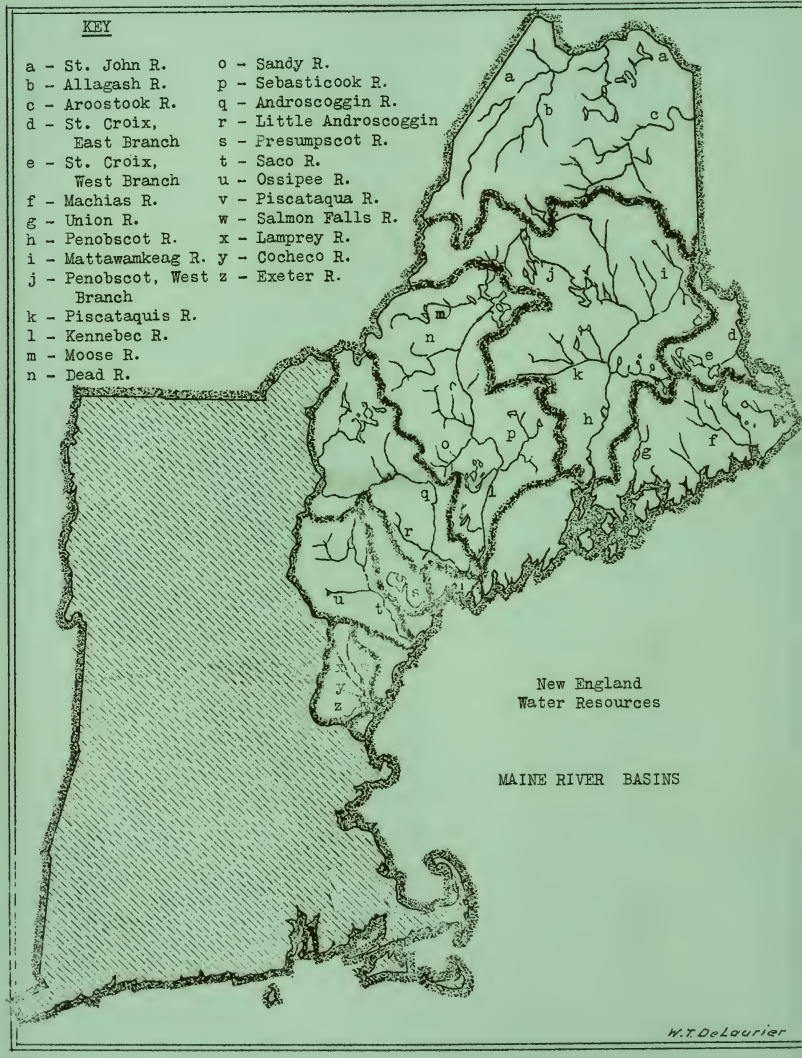

MAP Nº 4
SOURCE OF INFORMATION
U.S. WEATHER BUREAU
BOSTON MASS.
NEW ENGLAND
WATER RESOURCES
AVERAGE ANNUAL
PRECIPITATION
Legend
ISOPLUVIALS
WEATHER BUREAU (REGULAR STA)
WEATHER BUREAU (SUB-STATION)
SCALE
25 0 25 50
NEW ENGLAND-REGIONAL-PLANNING-COMMISSION
NATIONAL RESOURCES COMMITTEE
DISTRICT NO.1
2100 FEDERAL BUILDING
BOSTON MASSACHUSETTS
Van Buren
Houlton
Patten
Millinocket
Danforth
Greenville
The Forks
Oquossoc
Eastport
Orono
Old Town
Bar Harbor
Whitefield
Farmington
Rumford Falls
Winslow
Gardiner
No Bradgton
Lewiston
Cornish
Portland
Bloomfield
Bingham
Johnsburg
Northfield
Chelsea
Norwich
Hanover
Plymouth
Woodstock
Grafton
Franklin
Concord
Durham
Newton
Manchester
Kelene
Hillsboro
Rockport
Lowell
Lawrence
Salem
Boston
Provincetown
Plymouth
Middleboro
Fall River
Tiverton
Newport
Block Is.
Nantucket
Torrington
Hartford
Willimantic
Waterbury
Cobalt
Hawleyville
New Haven
Norwalk
Bridgeport


MAP Nº 5
SOURCE OF INFORMATION
U. S GEOLOGICAL SURVEY
STREAM GAGING STATIONS
NEW ENGLAND
WATER RESOURCES
MEAN ANNUAL STREAM FLOW
IN
NEW ENGLAND
JUNE 30 1937
Legend
20,000 CU. FT. PER SEC.
15,000
10,000
5,000
0
SCALE
25 0 25 50
NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT NO. 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS


MAP No6
SOURCE OF INFORMATION
THE UNITED STATES CENSUS FOR 1930
AND
POPULATION DISTRIBUTION MAPS OF
THE VARIOUS STATE PLANNING BOARDS
DISTRIBUTION
OF
POPULATION
IN
NEW ENGLAND
1930
SCALE IN MILES
Legend
DENSITY OF POPULATION IS SHOWN ACCORDING
TO THE GRADUATED SCALE INDICATED BELOW
LESS THAN 1
1 TO 30
30 TO 75
75 TO 100
100 TO 200
200 TO 500
500 TO 1000
1000 TO 5000
5000 TO 10000
10000 AND OVER
PEOPLE PER SQUARE MILE
WATERSHEDS
NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT NO 1
PANEL THREE BUILDING BOSTON MASSACHUSETTS


MAP Nº 7
ST JOHN
ANDROSCOGGIN
MEMPHREMAGOGG TRIBUTARIES
PENOBSCOT
ST CROIX
KENNEBEC
EASTERN MAINE COASTALS
CENTRAL MAINE COASTALS
CHAMPLAIN
SAGO
PRESUMPSCOT
MERRIMACK
MAINE - NEW HAMPSHIRE COASTALS
HUDSON TRIBUTARIES
CONNECTICUT
PISCATAQUA
MASSACHUSETTS COASTALS
THAMES
TAUNTON
HOUSATONIC
BLACKSTONE
NARRAGANSETT BAY - EASTERN CONNECTICUT COASTALS
WESTERN CONNECTICUT COASTALS
POPULATION GROWTH
IN
NEW ENGLAND CITIES AND TOWNS
1920-1930
Legend
GROWTH FACTOR
1001 AND OVER.
101 TO 1000
11 TO 100
10 AND UNDER
STATIONARY (WITHIN 1%)
LOSS
NEGLIGIBLE (POR UNDER 5%)
BOUNDARY OF RIVER BASINS
NOTE: GROWTH FACTOR IS NUMERICAL INCREASE TIMES PERCENT INCREASE. PURPOSE OF FACTOR IS TO AVOID GIVING UNDUE PROMINENCE TO COMMUNITIES HAVING A HIGH PERCENTAGE INCREASE BUT A NUMERICALLY SMALL POPULATION.
SOURCE OF DATA
U.S. CENSUS
PREPARED BY
NEW ENGLAND REGIONAL PLANNING COMMISSION
2100 FEDERAL BUILDING
BOSTON MASSACHUSETTS.

MAINE RIVER BASINS


KEY
a - St. John R.
b - Allagash R.
c - Aroostook R.
d - St. Croix, East Branch
e - St. Croix, West Branch
f - Machias R.
g - Union R.
h - Penobscot R.
i - Mattawamkeag R.
j - Penobscot, West Branch
k - Piscataquis R.
l - Kennebec R.
m - Moose R.
n - Dead R.
o - Sandy R.
p - Sebasticook R.
q - Androscoggin R.
r - Little Androscoggin
s - Presumpscot R.
t - Saco R.
u - Ossipee R.
v - Piscataqua R.
w - Salmon Falls R.
x - Lamprey R.
y - Cocheco R.
z - Exeter R.
New England
Water Resources
MAINE RIVER BASINS
W.T.DeLaurier

MAINE RIVER BASINS

This region comprises the entire state of Maine and that portion of New Hampshire which lies to the east of the Merrimack River Basin. The headwaters of several of the streams extend either into New Hampshire or Canada. The drainage basins considered separately in this section are the St. John, St. Croix, Eastern Maine Coastal, Penobscot, Central Maine Coastal, Kennebec, Androscoggin, Presumpscot, Saco, Piscataqua and Maine-New Hampshire Coastal. The St. John and St. Croix watersheds are international, and the Androscoggin, Saco and Piscataqua are interstate streams.

The area to the north and west of a line running northeast from the White Mountains to Mt. Katahdin and thence north to the St. John River is an extensive plateau region with an altitude approximately 1000 feet above sea level. From this imaginary line the land slopes toward the coast in an easterly and southerly direction. The topography of this coastal slope is extremely irregular, being characterized by many hills, valleys, ponds and lakes. The shore line is very uneven, as is borne out by the fact that the coastline of Maine consists of about 2500 miles of tidal shore while the air-line distance is about 250 miles.

The shore to the south of Portland, Maine, is in general sandy and there are numerous extensive beaches which stretch along the distance from Portland Harbor to the mouth of the Hampton River in New Hampshire. Eastward from Portland Harbor, the shore becomes increasingly rocky and rugged. The unusual tidal range, averaging 20 feet, which occurs along the northeast coast, coupled with the many good sized bays in this sector, has suggested the possibility of developing tidal power in this locality.

The total area of the region is about 34,900 square miles, of which 32,600 square miles are in Maine and 2300 square miles are in New Hampshire. Forest growth covers between 70 and 80% of the area, located principally in the northern two-thirds of the region. There are more than 1400 rivers and streams and more than 2200 ponds and lakes with water surfaces comprising close to 1500 square miles. The result of the addition of artificial storage to this existing natural storage has been to give a high development of storage per square mile.

Floods on the Maine rivers occur for the most part in the spring and are occasioned by heavy rainfall and melting snow. Up to March 1936, flood flows had not been excessive and no flood prior to that date had caused damages in excess of $500,000. Damages were confined principally to bridges and other structures which impeded the flow of the stream. The damages from the 1936 flood totaled nearly $8,000,000.

The water power of Maine constitutes one of its most valued resources. It is estimated that over 1,000,000 horsepower are available for economic development, and of this amount over 675,000 horsepower are at present developed by installations of over 100 horsepower capacity.

A peculiar feature of the power situation in this region is that the Maine statutes forbid the exportation of any power. This limits the expansion of public utility companies. In an average year there is a surplus of secondary power for which there is relatively little demand within the state of Maine, prime power being at present the only power which finds a market. The limitation imposed by the Maine Statute has an important retarding influence on the development of potential power sites on Maine rivers.

The rugged coastline of Maine, with its innumerable bays and harbors, affords excellent navigation opportunities. Over 100 miles of navigable tidewater rivers are used for water-borne commerce. Present facilities are, in general, adequate for the accommodation of vessels although some improvements, such as construction of breakwaters and deepening of channels and anchorages, are needed.

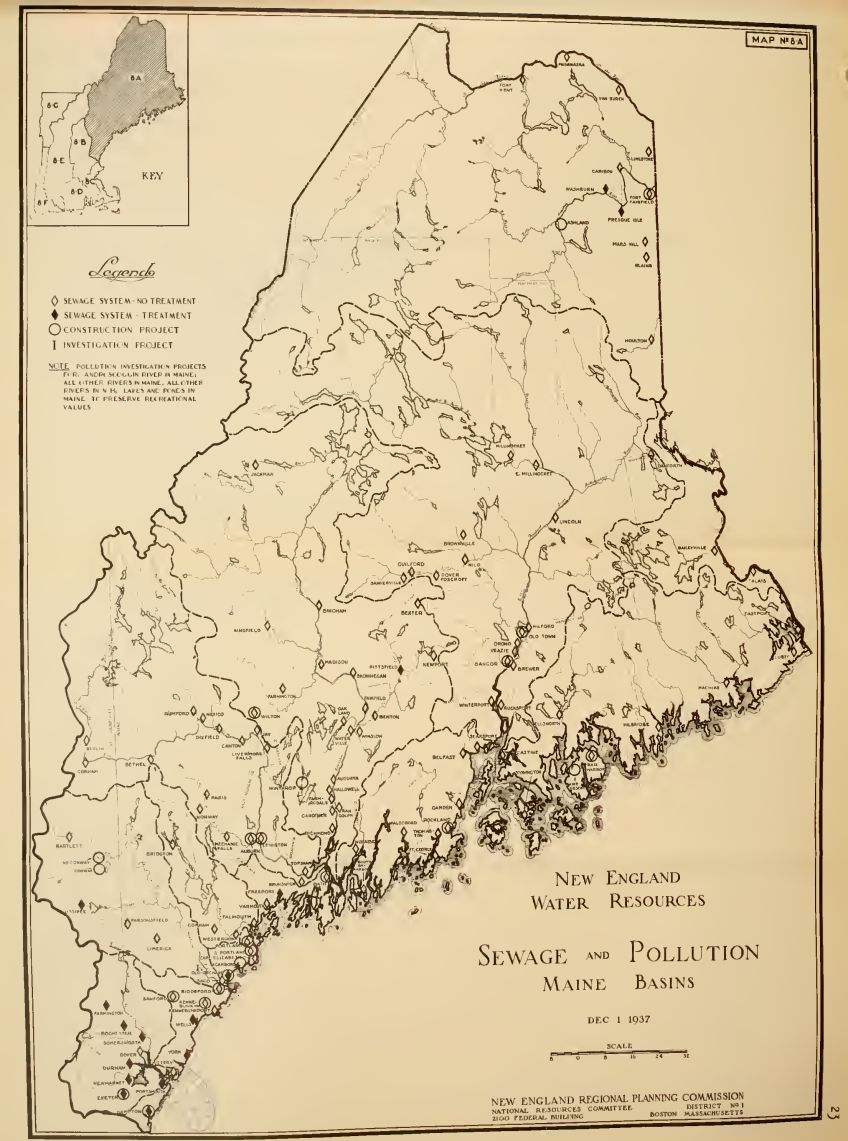
Numerous low-lying marshlands along the coast afford ideal mosquito breeding places. The attractiveness of many of these areas for recreational use is lessened by the presence of this pest. From this point of view, drainage of swamps and marshes would, in many cases, be desirable. However, drainage of these lands would be detrimental to wildlife conservation in that it would destroy the natural habitat and shelter for fish, game and waterfowl. Owing to this conflict of interests, the drainage problem involves the relative values of reclamation and wildlife protection.

Recreation draws annually into this region a volume of business exceeding $100,000,000. This business is scattered through all parts of the area, with most intensive concentrations in the coastal, mountain and inland lake regions. Recreational services stand clearly as the highest social and economic activities possible in many of these coastal, lake and mountain areas.

Pollution from untreated domestic sewage and industrial wastes presents a problem which is becoming increasingly important in its relation to the use of rivers and lakes for recreational purposes. The rivers are so large in proportion to the population and industrial developments along their banks that they can absorb without deleterious results most of the sewage and trade wastes. The moderately-sized cities and towns along the rivers do not, as a rule, contribute sewage in amounts sufficiently large to overburden the diluting capacity of the rivers; and it is in only a few localities that nuisances are found. However, with the growing population density in various industrial centers, the point is being approached where objectionable sanitary conditions will result. Of all the rivers in Maine, the Androscoggin presents the most urgent problem.

With respect to public water supplies the present needs of the region are mostly of local significance. The many lakes and ponds scattered throughout the area afford adequate surface sources, and in most sections underground water can be easily obtained. Less than a dozen communities where there are as many as 200 houses are without public supply systems. In numerous cases established systems need extensions and improvements, and in a few cases the location of new or supplementary sources of supply will become necessary if population growth continues.

MAP Nº 10-A
KEY
Legend
D DRAINAGE
HC HEADWATERS CONTROL
N NAVIGATION
P POWER AND POWER STORAGE
W WILDLIFE CONSERVATION
I INVESTIGATION OR STUDY PROJECT
BASIN-WIDE PROJECT
NATIONAL FOREST PROJECT
NEW ENGLAND WATER RESOURCES
RECOMMENDED PROJECTS
EXCEPT WATER SUPPLY AND POLLUTION PROJECTS
MAINE BASINS
DEC. 1, 1937
SCALE
NOTE: PROJECT NOT MAPPED WOULD PROVIDE NEW STATIONS TO COLLECT HYDROLOGIC DATA.
NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS
AUGUSTA
EASTPORT
CAPE ELIZABETH
OLD ORCHARD
KITTERY
RYE HARBOR


MAP N°8A
8A
8C
8B
8E
8D
8F
KEY
Legend
SEWAGE SYSTEM - NO TREATMENT
SEWAGE SYSTEM - TREATMENT
CONSTRUCTION PROJECT
INVESTIGATION PROJECT
NOTE POLLUTION INVESTIGATION PROJECTS FOR ANDROSCOGGIN RIVER IN MAINE, ALL OTHER RIVERS IN MAINE, ALL OTHER RIVERS IN N.H. LAKES AND PONDS IN MAINE TO PRESERVE RECREATIONAL VALUES
NEW ENGLAND
WATER RESOURCES
SEWAGE AND POLLUTION
MAINE BASINS
DEC 1 1937
SCALE
0 4 8 16 24 32
NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT NO 1
860 FEDERAL BUILDING BOSTON MASSACHUSETTS

MAP Nº 9A

Legend

- △ WELL, ○ SPRING, □ SURFACE — NO TREATMENT
- ◬ WELL, ◎ SPRING, ⊡ SURFACE — TREATED WITH DISINFECTANT
- ▲ WELL, ◑ SPRING, ◨ SURFACE — TREATED MECHANICALLY
- ▲ WELL, ● SPRING, ■ SURFACE — MECHANICALLY TREATED AND DISINFECTED
- INSIDE SYMBOL OF SUPERIMPOSED SYMBOLS INDICATES TREATMENT OF ALL.
- ○ SUGGESTED PROJECT

NEW ENGLAND WATER RESOURCES

WATER SUPPLIES MAINE BASINS

NOTE: INVESTIGATION PROJECTS FOR WATER SUPPLY REQUIREMENTS OF ALL TOWNS AND CITIES IN MAINE AND NEW HAMPSHIRE.

DEC. 1, 1937

SCALE 0 5 8 16 24 32

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT NO 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

ST. JOHN BASIN

GENERAL DESCRIPTION

The St. John River Basin, the largest between the St. Lawrence and the Susquehanna, has a total drainage area of 26,000 square miles, of which about 7200 square miles cover the entire northern section of the state of Maine. The river rises in the mountainous region between Maine and Canada, and, from the junction of the northwest and southwest branches, where the river first takes its name, to the junction with the St. Francis River, a distance of about 90 miles, its generally northeast course lies wholly within the state of Maine, although a portion of its tributary drainage is in Canada. Eastward from the mouth of the St. Francis River almost to Grand Falls, New Brunswick, a distance of about 70 miles, the river forms the international boundary line between the United States and Canada.

At a point about three miles above Grand Falls the river leaves the international boundary and flows southeasterly through New Brunswick for about 200 miles, entering the Bay of Fundy at St. John. The total length of the river is about 450 miles, of which about 160 miles is in the United States.

The St. John basin is predominantly a plateau region, sloping gradually northeastward. More than two-thirds of the area is 1000 feet or more in elevation, while only a small portion, along the Aroostook River, has an altitude of less than 500 feet. In the eastern portion of the basin, the terrain is comparatively level in the floor of the river valley, but gradually becomes hilly and undulating, and finally merges into flat country bordering the Aroostook River. Above the mouths of the St. Francis and the Allagash Rivers the basin is diversified by highlands.

Clays and slates are found throughout 75% of the basin, the prevailing rocks in the eastern part of the area being limestone and slate, with patches of granite, coarse rock and sandstone. The overburden is composed of glacial drift and clays. The whole region has the characteristics of glaciated topography.

Over 75% of the St. John basin is under a heavy forest cover, of which soft woods are the predominant type. Little virgin timber remains, but lumbering, particularly for pulp wood, is still the most important industry in the valley. Timber cut in the more remote portions is driven down the streams and tributaries to mills along the main river. Ten percent of the total area is crop land, located in the towns along the Aroostook River and the international portion of the St. John.

The annual precipitation ranges from about 31 inches at Houlton to over 36 inches at Van Buren. These amounts are somewhat less than occur in other parts of New England. The precipitation of the summer and early fall exceeds that occurring during other parts of the year. The temperature varies considerably according to the distance from the ocean. The average winter temperature is from 5° to 15° and the summer temperature from 60° to 65°. The growing season is usually between 90 and 100 days.

The three principal Maine tributaries to the St. John are the Allagash, Fish, and Aroostook Rivers. The Allagash rises in the lakes of northern Piscataquis County and flows north a distance of about 80 miles through wild uninhabited country to the St. John, which it enters about 10 miles upstream from the international boundary. The natural drainage area of the Allagash is about 1490 square miles, but the runoff from the 240 square miles of this area which drain into Chamberlain and Telos Lakes has been diverted to the East Branch of the Penobscot River.

The Fish River rises in central Aroostook County and follows an irregular course through many lakes, the largest of which is Eagle Lake, to its confluence with the St. John River at Fort Kent on the Canadian border. The area drained by the Fish River comprises about 890 square miles of largely wooded country.

The Aroostook River rises in north central Maine and winds through a comparatively level country for about 120 miles in a generally northeast direction to the Canadian border and then east about five miles to join the St. John River. About 2350 square miles of the drainage area is in Maine.

Discharge records are kept by the U. S. Geological Survey in co-operation with the state of Maine at four gaging stations on the St. John and its tributaries. Detailed data for these stations can be found in the U. S. Geological Survey Water Supply Papers, Part I--North Atlantic Slope Basins. The figures in Table III-A are summarized from unpublished records in the office of the District Engineer at Augusta and from the published Papers of the Survey.

The hydrograph on Chart 1 shows the average monthly runoff during the last 10 years at Fort Kent on the St. John River. The average runoff over a ten-year period from the drainage area of 5690 square miles at this station is 1.74 cubic feet per second per square mile.

HUMAN OCCUPANCY

Population The Maine portion of the watershed had a population of only 80,000 in 1930. This meant that one-fourth of the state area contained only one-tenth of the total state population. Three-fourths of the basin is uninhabited, but the northeastern Aroostook potato-growing region has a population density of about 30 per square mile. Between 1920 and 1930 the population, nine-tenths of which is rural, increased about 7%, or twice as fast as the state as a whole.

The region contains only four towns of 5000 to 10,000 population - Caribou, Presque Isle, Fort Fairfield and Houlton - all important trading centers in the potato-growing area. Van Buren (pop. 4721) and Fort Kent (pop. 4726) and Madawaska (pop. 3533), all located on the St. John River, are the only other towns with more than 2500 inhabitants.

The rate of population increase for this basin between 1900 and 1930 was about 45%, three times that for the entire state. The rate fell, however, from 23% between 1900 and 1910 to 7.% between 1920 and 1930. Relative changes of town populations for this period are shown on map 7-A. These trends and the agricultural possibilities of the region indicate a much higher rate of increase for the future here than elsewhere in the state.

Agriculture Outside of the wilderness region rural territory comprises 14 towns and plantations with populations between 1000 and 2500, and many hamlets and farming districts. The foundation of farming in Aroostook County is its potato crop, which amounts to over four-fifths of the state crop and about one-eighth of the crop of the entire country. Its value in 1933 was nearly $25,000,000 - about half as much as the value of Maine's pulp and paper products. The average value of farm land in this section is double that of land in the state as a whole. The potato industry gives employment to about 50% of the workers engaged in farming in all of Maine and accounts for the relatively large population and the prosperity of Aroostook County.

Agricultural development depends on success in growing and marketing the potato crop. Continued improvement in marketing methods is important on account of severe competition from the West

Industry . Aside from a limited amount of manufacturing in which forest products are utilized, there is very little manufacturing, the total production value for 1933 being less than $6,000,000. Most of the plants are located on the St. John River. Remoteness from sources of supplies of materials other than timber, as well as from markets, precludes any extensive industrial development except in the production of pulpwood and lumber.

As there are no large undeveloped water powers, there are no special inducements for manufacturers to locate at sites along these rivers rather than on rivers in southern Maine.

Mining Mining enterprises, once active, are very limited and consist of the extraction of small amounts of lime for fertilizer.

Lumbering Although a comparatively small industry, lumbering is at present important on account of the volume of spruce that is cut for pulpwood. Also a large amount of timber, principally spruce, is taken out and floated to mills located along the principal rivers. To meet the needs of log driving, conservation of water is regarded as a vital problem.

Recreation . The vast wilderness in this watershed offers exceptional opportunities for canoeing, fishing, and hunting of large and small game. Facilities for visitors are available in numerous sporting camps located on the many lakes and streams. On account of its comparative remoteness this section is not visited by so many vacationists as the more southerly parts of Maine, but it is probable that improved transportation conditions will lead to increased use of its recreational resources.

Transportation Water transportation is practically confined to the flotation of pulpwood and logs to mills on the St. John River and tributaries. Because lumbering is the all-important industry of the region, sufficient flowage for driving logs down-stream to points of use is a vital question and takes precedence over any other feature of river development.

The settled northeast section of the basin is served by one state and one Federal Highway running north and south which connect with Bangor and other points in Maine as well as with Canadian routes along the northern and eastern boundaries. The poor condition of some of the secondary roads and the lack of farm-to-market roads are handicaps, especially to commercial trucking.

Railroad transportation is provided by the Bangor and Aroostook R. R. connecting Houlton and points north with Bangor. Connections to New Brunswick points are provided by branches of the Canadian Pacific Railway running to Houlton and up the St. John River to Presque Isle. There is urgent need in the interest of agriculture and trade for improved railroad service and lower rates.

Scheduled air service has recently been established from Bangor, through Houlton to Presque Isle and Caribou. Landing fields now in operation in these towns are used also to a considerable extent for non-scheduled flying.

WATER USE AND CONTROL

Pollution Above the confluence of the Allagash and St. John Rivers the Maine portion of the St. John basin is virtually uninhabited, as most of the 80,000 people living in the watershed occupy the lands to the east. The largest town, Caribou, has a population of 7248, and only seven other towns have populations exceeding 2000.

Pollution conditions of the river have not been intensively studied and consequently there is little information available either in Maine or Canada. Any complete appraisal of sanitary conditions in the St. John basin must be made on an international basis. The information now available indicates that the condition is not serious except with respect to the curtailment of fish life in the main streams. Although it is uncertain whether a river investigation would disclose conditions the cost of correction of which would be justified, nevertheless there is need for the collection of additional data.

Table IV-A, shows that Fort Kent (pop.4726), Van Buren (pop.4721), and Ashland (pop.2198) are the largest towns without sewer systems.

Only two communities treat their sewage. Presque Isle, on the Aroostook River, has the most modern disposal works in the state. Washburn, a short distance upstream from Presque Isle, also treats its sewage, but by antiquated methods. Houlton (pop.6865) discharges raw sewage to the Meduxnekeag River, which joins the St. John at Woodstock, New Brunswick. If consideration could be given to the provision of partial treatment of Houlton's sewage it would constitute an important step in a program of abatement of industrial pollution.

The largest single source of industrial pollution is the waste from the pulp and paper mills at Madawaska. There are a number of starch factories in the basin, four of them in Fort Fairfield, the wastes from which have a decided affinity for oxygen and are therefore deleterious to the abundant fish life in this region; also the discharge of raw or partially treated domestic sewage into the lakes and ponds of this area is detrimental not only to fish life but to general sanitation as well.

Water Supply Many of the larger communities in the basin are served by semi-public water supplies drawn mostly from surface sources; in a few cases the water is chlorinated. Towns comprising 53% of the basin population have supplies. These towns are listed in Table V-A.

The populations of the larger communities which do not have supplies are:

Ashland	2198	Monticello	1467
Eagle Lake	1780	St. Francis	1367
St. Agatha	1596	Mapleton	1283
Frenchville	1525	Wallagrass	1145

The census figures do not indicate the population increase during the summer due to vacationists. The towns listed above might well contemplate the construction of water systems for protection of the public health and prevention of fire. There is ample opportunity for developing new surface and ground water supplies, although the terrain in the settled regions is flat.

Various industrial processes, particularly paper manufacture, present water supply problems which must be recognized in any summary of conditions in the St. John basin.

Flood Control Flood flows on the St. John have not been high nor have flood losses been great. The low flood damage is due to the fact that there are few structures within the flood plains. The March, 1936, flow was the largest on record at Washburn on the Aroostook River, but at the other three gaging stations in the basin the maximum flows occurred in 1933. The discharge in May, 1923, may have exceeded the 1933 and 1936 flows as it did on the rivers to the south, but no records are available for that year.

Most of the area has not been topographically mapped and only approximate information is available regarding the possibilities for storage. A report of the International Commission suggested that in many cases dams be raised and indicated what storage increase might be obtained thereby. Table IX-A shows the possible additional amounts of storage for the several lakes and ponds on the tributaries of the St. John River as given in that report.

This river is more useful for log-driving than for any other purpose and consequently, in any consideration of development affecting regulation and control of stream flow on the river, precedence should be given to this use. For more than a century Maine rivers have been intensively used for the transportation of logs from the forests to the saw and pulp mills. Many improvements and devices have been established to facilitate this important commercial use of the river. However, its rocky channel and numerous shallows make log driving difficult and hazardous. Development of storage would improve conditions by increasing the stream flow during the log driving season; hence future storage developments would be of benefit to log driving as well as to power and to flood control.

Power Although the upper two-thirds of the St. John basin is high plateau, the slope of the river is, with few exceptions, comparatively uniform, so that there are few sites on the main river where development of water power would be feasible. The same is true, to a lesser degree, on the tributaries. The total developed and undeveloped power in the St. John basin, as given in the 1928 report of the Maine Public Utility Commission, is 51,650 horsepower.

According to the U. S. Geological Survey's unpublished list of Water Powers in Maine, only 1290 horsepower are at present developed. This is developed by the Caribou Water, Light and Power Company, at Caribou, on the Aroostook River, with a wheel installation of 1040 horsepower, and by a small mill at Houlton, on the south branch of the Meduxnekeag River, with an installed capacity of 250 horsepower.

In the upper St. John, above the mouthof the Allagash, the slope of the river is fairly uniform, averaging about 5 or 6 feet per mile. In this area there are but few opportunities for storage, which fact, coupled with the small amount of fall, makes the available power of little consequence.

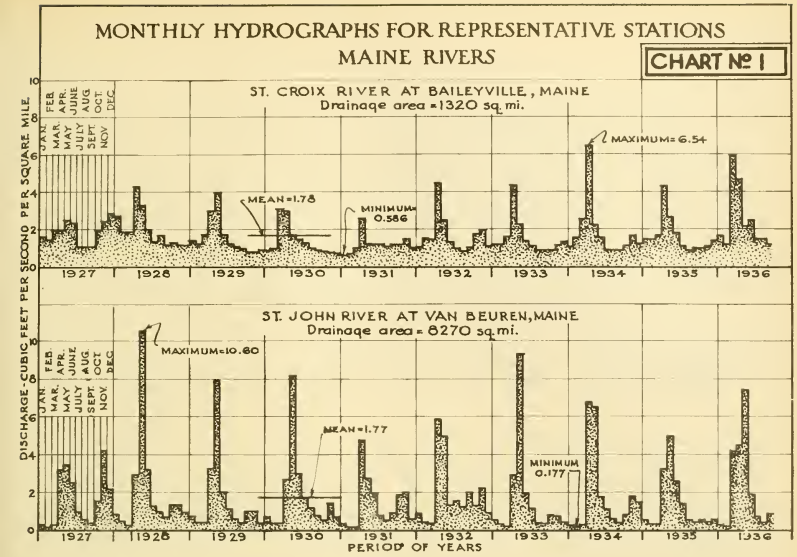
About 360 feet of fall occur in the Allagash River in the 77 miles below Chamberlain Lake. Between Churchill and Long Lakes, a distance of about 6 miles, there is a fall of approximately 100 feet, and between Long Lake and Round Pond, a distance of 10 miles, there is a fall of 40 feet. The extensive fall in the Allagash, together with its fine storage facilities, affords the best opportunities for power development to be found on any of the tributaries of the St. John River.

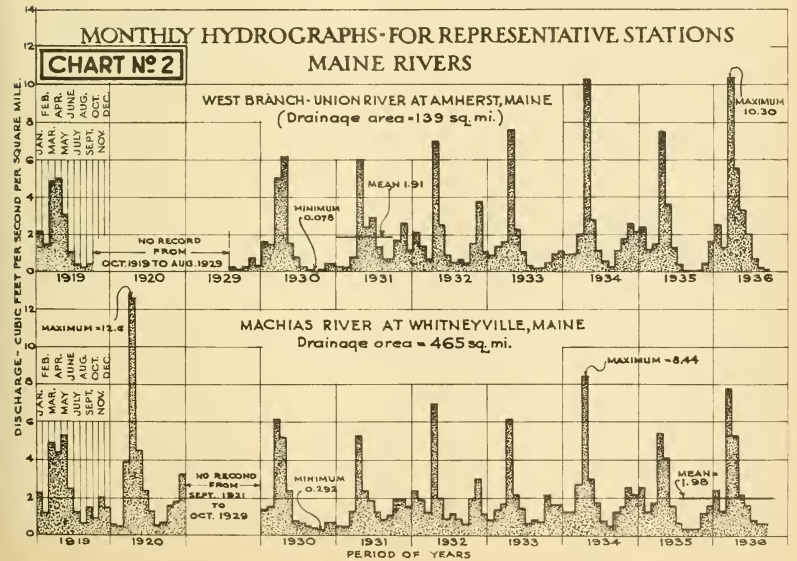
The possibilities for storage on Fish River are adequate to enable good regulation of the flow in the river and hence to make available a considerable increase in prime power at the sites between Eagle Lake and the river's mouth, in which distance of 12 miles a fall of 80 feet occurs.

The St. Francis and Madawaska Rivers offer small possibilities for power development but there are in these basins good storage facilities which would benefit sites on the main river below.

The fact that so large a proportion of the available power is still undeveloped is due in no small measure to the physical and economic characteristics of the region. Sparsely inhabited, and remotely situated with respect to markets and sources of raw materials, the demand for power in this region is very small. Furthermore, there is little rural electrification in this section. Any increased demand for power in the Aroostook region is met at present by plants located on the rivers to the south, because the extension of transmission lines to this northern area has proved more economical than the construction of new plants within the basin. Although the supply of electrical power in the St. John valley is adequate for present needs, it might be possible to obtain power more economically by redeveloping some of the existing sites.

Any heavy increase in demand for power in this area will be due either to an influx of manufacturing plants or to a marked extension of rural electrification. Here, too, the location of this area with respect to markets and sources of raw materials makes improbable any significant increase in industrial development. Furthermore, without an appreciable reduction in rates, it is unlikely that rural electrification in this area will become extensive. In view of the unpromising future for increased power requirements, additional water power installations on this river are not anticipated.


MONTHLY HYDROGRAPHS FOR REPRESENTATIVE STATIONS
MAINE RIVERS
CHART Nº 1
ST. CROIX RIVER AT BAILEYVILLE, MAINE
Drainage area =1320 sq. mi.
MAXIMUM=6.54
MEAN=1.78
MINIMUM=0.586
ST. JOHN RIVER AT VAN BEUREN, MAINE
Drainage area = 8270 sq. mi.
MAXIMUM=10.80
MEAN=1.77
MINIMUM 0.177
DISCHARGE - CUBIC FEET PER SECOND PER SQUARE MILE
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
1927 1928 1929 1930 1931 1932 1933 1934 1935 1936
PERIOD OF YEARS


MONTHLY HYDROGRAPHS - FOR REPRESENTATIVE STATIONS
MAINE RIVERS
CHART Nº 2
WEST BRANCH - UNION RIVER AT AMHERST, MAINE
(Drainage area = 139 sq. mi.)
MAXIMUM 10.30
MEAN 1.91
MINIMUM 0.078
NO RECORD FROM OCT. 1919 TO AUG. 1929
MACHIAS RIVER AT WHITNEYVILLE, MAINE
Drainage area = 465 sq. mi.
MAXIMUM = 12.6
MAXIMUM = 8.44
MEAN = 1.98
MINIMUM 0.292
NO RECORD FROM SEPT. 1921 TO OCT. 1929
DISCHARGE - CUBIC FEET PER SECOND PER SQUARE MILE
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
1919 1920 1929 1930 1931 1932 1933 1934 1935 1936
PERIOD OF YEARS

Erosion Over half the area in Maine which has suffered the loss of from one-fourth to three-fourths of the topsoil lies in Aroostook County. Practically all of these 600,000 acres are drained by the St John, although a small section in the vicinity of Island Falls is drained by the Penobscot. Moderate sheet erosion is active, and extensive areas have been attacked by occasional gullies. Corrective practices, now being applied in some localities, must eventually extend to nearly all the potato farms in the Aroostook region.

Navigation The navigable waters of the St. John lie wholly in Canada, and are not sufficiently affected by conditions obtaining in the Maine portion of the basin to warrant consideration of them in this report.

Drainage The scattered locations where artificial drainage is desirable are almost wholly restricted to those where improvements are needed to reduce local mosquito nuisances. Nowhere is the nuisance so great as to demand immediate action.

Recreation The recreationist or sportsman who prefers a genuinely wild, and uninhabited forest region finds satisfaction in the streams comprising the headwaters of the St. John system. This wild area extends over approximately 5000 square miles of the basin. There are only two practical means of visiting and exploring the section -- the canoe and the pontoon-equipped aeroplane. Sportsmen, in recent seasons, have made a steadily increasing use of the aeroplane to reach the lakes and ponds sprinkling the forested regions of the St. John watershed. The Maine Forest Service and the Department of Inland Fisheries and Game have acquired planes for efficient and prompt administration of their duties in the extensive Maine wildlands, of which the St. John drains about one-third. Although the aeroplane has opened a practical means of transportation for the hurried or lazy individual who wishes to enjoy the wilderness, the adventurous still pole and paddle canoes. The famous Allagash River canoe trip, 145 miles long, and the St. John River trip, 201 miles, demand rugged self-sufficiency but return in full measure natural beauty and sport. While hotels and sporting camps have exploited the Aroostook and Fish River valleys, they have thus far penetrated the upper St. John for only a few miles above the St. Francis River.

Due to low population density of the St. John, most of the wildlife and recreational assets of the basin have escaped destruction. The outstanding problem is how to safeguard these assets and at the same time to encourage reasonable recreational, agricultural and industrial expansion.

ST. CROIX BASIN

GENERAL DESCRIPTION

The St. Croix River is formed by the junction of the upper St. Croix, or East Branch, and the West Branch. The East Branch flows out of the Chiputneticook Lake system in a southerly direction to Calais, at the head of tidewater. The West Branch rises in the Grand Lakes system, in west central Washington County, and flows easterly for 25 miles, meeting the East Branch about 20 miles above Calais. The total drainage above Calais is about 1470 square miles, of which 1050 square miles are in Maine. The total length of the waterway, including both branches, is 100 miles. The length of the basin is about 60 miles; its breadth 50 miles.

The basin is generally low in elevation and comparatively level, except for some rolling country along the northern divide. Numerous lakes throughout the watershed have a total area of 136 square miles, or more than 13% of the drainage area in Maine.

The bedrock is principally granite and limestone. The only soils of agricultural value are silt-loams and clays along the lower reaches of the river, the overburden of the remainder of the area being stony soil. Less than 10% of the area is in pasture or crop land, the remainder being heavily wooded or cut over.

The precipitation in the St. Croix basin averages about 41 inches yearly, with slightly less rainfall in the spring and early summer than during the rest of the year. The average winter temperature is from 16° to 20°, and the summer average about 65°.

There are no large tributaries to the St. Croix River other than the East Branch and West Branch mentioned above, which unite to form the main river. The East Branch has a drainage area in Maine and Canada of 644 square miles, 50 square miles of which are water area. The West Branch drains 674 square miles, of which 85 square miles are water area. The average fall of the river between the lake outlets and tidewater at Calais is about 7 feet per mile, much of which is concentrated at a few points.

Discharge records are kept at three stations by the U. S. Geological Survey in cooperation with the state of Maine. Detailed data for these gaging stations can be found in the U. S. Geological Survey Water Supply Papers, Part I --North Atlantic Slope Basins. The figures in Table III-A are summarized from unpublished records in the office of the District Engineer at Augusta and also from the published papers of the Survey.

The hydrograph on Chart 1 shows the average monthly runoff during the past 10 years at Baileyville, Maine. The average runoff from the drainage area of 1320 square miles, over a ten-year period, is 1.56 cubic feet per second per square mile.

HUMAN OCCUPANCY

Population In 1930 that portion of the St. Croix Basin lying in Maine had a population of approximately 13,000 and an average density of about 12 per square mile. With the exception of Calais, the principal town, with a population of 5,470, there is no urban population; the only other sizable town is Baileyville, with 2017 inhabitants. The remaining inhabitants are found in a few small villages along the lower river and in scattered farm and forest locations.

The loss or gain of population by towns between 1920 and 1930 is indicated on Map 7. Of 24 towns 14 lost in this period, the total net decline for the watershed being 1000 inhabitants. No towns gained consistently between 1900 and 1930. As the villages depend principally on small manufacturing enterprises for their existence, there will probably be a further decline in the number of inhabitants unless there is a revival of manufacturing.

Agriculture The basin contains about 350 farms, comprising less than 10% of the total area, and located for the most part in the southern section. The average value of farm land in the basin is considerably below the state average, and farm revenue for the entire basin totals about $350,000 per year. Dairy products and blueberries are the principal sources of farm income.

Industry The limited amount of manufacturing is confined to that of pulp and paper, lumber products and shoes. There are also two small plants where farm and sea products are canned. In all, only about 1000 people are employed in these industries.

No expansion of manufacturing is likely unless general conditions justify the building of new plants or the re-building of existing plants. This is a remote possibility because the region is so far from population centers.

Mining There are granite quarries in Calais and in one other town, and one lime quarry. The volume of production is small.

Lumbering Lumbering is an important activity, the chief product being pulpwood. There are also produced cedar ties and pine, spruce and hardwood logs, the output in 1934 amounting to about 1,500,000 board feet. Hardwood products are generally exported and the softwood are used locally.

Fishing The canning of sea food is carried on on a small scale, giving employment to less than 200 people. Aside from this activity, fishing is of little importance due to lack of accessible markets.

Recreation The St. Croix basin includes the main portion of the Grand Lake Stream region, the second largest wildlife area in New England. Moose, bear, deer, waterfowl, trout, bass, salmon and pickerel abound in this famous hunting and fishing ground. A few sporting camps cater to the public but there is very little development for other recreational activities. This is probably due to the fact that it lies so near the seashore resorts of New Brunswick and of the Penobscot Bay region.

Transportation The St. Croix River is navigable from its outlet in Passamaquoddy Bay to Calais. The channel depth, 9 feet at mean low water, accommodates commercial vessels. The moderate volume of traffic is principally in pulpwood and coal.

A trunk highway crosses the basin through Calais and the settled areas to the northern section and provides the chief medium of contact with outside points. This, with connecting public and private roads, is adequate to meet present requirements, but redevelopment has been recommended as desirable in anticipation of future needs.

Railway transportation in the basin is provided by a line of the Maine Central from Bangor running along the coast to Calais and by the main line of the Maine Central from Bangor to the Provinces which crosses the St. Croix River at Vanceboro.

There is no scheduled air transportation in this basin and only one landing field, at Calais. An airway development has been suggested, however, from Bangor through Calais to the maritime provinces. Due to the semi-wilderness character of the terrain and to the many lakes in the area, planes on floats would normally be preferable to land planes.

WATER USE AND CONTROL

Pollution Baileyville and Calais are the only communities in the basin that have populations of more than 2000. These two communities are the principal sources of domestic and industrial pollution, and the pulp and paper industry at Baileyville makes that town the largest single contributor of manufacturing waste.

Little is known of the details of pollution problems on the Maine side. Any complete study of this river should take into account the volume and character of wastes discharged in the Canadian portion of the watershed as well as in the Maine portion.

If recreational developments become extensive, the sanitary conditions of the lakes may require investigation. The preservation of the existing fish habitats in Grand Lake stream and other waters is important, and precautions should be taken to guard against all pollution which is detrimental to fish life.

Water Supply The two largest communities, Calais and Baileyville, containing 60% of the basin population, have water supply systems. Baileyville utilizes the St. Croix, after filtration and chlorination, while Calais has ground water sources. The four largest towns without supplies are Princeton (pop.915) Waite (pop.713) Vanceboro (pop.713) and Robbinston (pop.583). In general, the water supply needs in this basin are not urgent, but if they do become so, it will be possible to develop new ground and surface sources.

Flood Control The relatively large natural storage in the basin reduces materially the flood hazard on the St. Croix River. At the lower end of the river the banks are sufficiently high to keep flood discharges within the channel. The flood of 1923, which caused damage on streams to the south and west, caused very little damage on the St. Croix, the peak discharge at Woodland amounting to only 17.7 c.f.s./s.m. In 1936 there were no severe flood conditions on the river.

The lack of good storage sites, the impracticability of raising water levels in the lakes and ponds, and the comparative freedom from flood damages combine to make unnecessary any flood control measures for the St. Croix River.

Power The St. Croix River has been developed for power for more than a century. In the early days the installations were confined to several small privileges in the lower part of the river, whereas present developments in Maine utilize 124 feet of head and have a total installed capacity of 26,760 horsepower. House Document #643, 71st Congress, 3rd Session gives 5030 horsepower for installations on the Canadian side of the river under a total head of 50 feet. Present demands for power are fully met by the existing developments.

The principal Maine developments on the St. Croix River are those at Woodland and Grand Falls. At the former site, 13,200 horsepower are developed under a head of 47 feet; at Grand Falls, the wheel capacity is 12,950 horsepower, with a head of 49 feet; at Mill Town there is a third development which amounts to only 610 horsepower.

According to the Army Engineers' Report, 519 feet of head, most of which is on the Canadian side, can still be utilized with wheel installations of something over 22,000 horsepower. On the American side, the sites which have present economic possibilities are at Mill Town, Baring and a point between Big Lake and Grand Lake on the West Branch. The first two are the most valuable. At the Mill Town site, a redevelopment might be made to produce 4,685 horsepower 50% of the time and 2650 horsepower 90% of the time. Redevelopment at Baring would produce power increase of only 1900 horsepower on a 50% time basis, and 1040 on a 90% time basis. The installation between Big Lake and Grand Lake on the West Branch would utilize a head of 80 feet and would develop 2180 horsepower on a 50% time basis and 1220 horsepower on a 90% time basis.

The basin is well supplied with lakes and ponds whose combined area is about 136 square miles, or 9.25% of the total basin. The larger lakes, controlled by dams at the outlets, have a combined storage of about 585,000 acre-feet. As only about 1/3 of the drainage area lies below the outlets of the lakes and ponds, correspondingly, only about 1/3 of the runoff reaches the streams directly, with the result that the runoff from the area is considerably retarded.

There is little opportunity to increase the existing storage by raising lake levels because their shores are so flat. Any increase in lake storage would result in extensive flowage over adjacent lands and would undoubtedly prove costly.

Navigation The river is navigable in the 14 miles of tidal portion below Calais. At Calais the project depth at mean low water is 12 feet at the lower steamboat wharf and 9 feet from that point upstream to the International bridge. The mean tidal range of 20 feet is an important factor in maintaining an average navigation season of about nine months.

Traffic on this estuary, during 1935, is reported by the Chief of Engineers to have been 17,724 tons, of which nearly one-third consisted of fertilizing materials. Probably most of these materials were bound for the Aroostook potato region just north of the St. Croix basin.

Erosion The portion of the basin lying in Maine has no erosion problems except in that area along the stream between Baring and Calais.

Drainage The basin is characterized by swamps and bogs which stabilize stream flow, shelter native and migratory wildlife, and support wood producing stands of spruce, fir, cedar and tamarack. Extensive drainage would not only be detrimental to the botannical and zoological life now occupying the wet lands but would also be of quiestionable economic value. In certain locations near settlements, drainage to abate the mosquito nuisance is desirable, although the municipalities are not now able to finance such undertakings.

Recreation Present recreational trends do not indicate a clearcut probability of expansion except in the field of sports. Construction of fish-ways on the lower St. Croix would reopen a natural travel route for Atlantic salmon and other fish. The entire western section of the basin lies within the authorized purchase unit of the Grand Lake National Forest, and when this area has been acquired it will be, under the administration of the U. S. Forest Service, devoted to forestry, wildlife preservation, and wilderness recreation.

EASTERN MAINE COASTAL BASIN

GENERAL DESCRIPTION

The Eastern Maine coastal basin comprises the area drained by several small coastal streams between the St. Croix and Penobscot basins. The largest of these streams are the Machias and Union Rivers. The district is about 100 miles long, extending inland for a maximum distance of about 60 miles. The total area is about 2550 square miles, 6% of which is water area.

The land is, in general, low and of irregular topography, with occasional hills about 1000 feet in altitude. The principal rock is granite and gneiss, with many local deposits of metallic pyrites. The soils in this coastal basin are chiefly sand and gravel and not well suited to agriculture. Less than 10% of the area is cleared farm land; the major portion is covered with virgin or cut-over soft woods.

The northeast coast provides natural tidal basins, with a total area of about 37 square miles, which are adapted to the development of power by harnessing the tide, the rise and fall of which averages about 20 feet.

The annual precipitation, averaging about 42 inches, varies from 38 to 48 inches, the greater amount occurring in the southwest part of the basin. The average winter temperature is 24° on the coast and about 18° near the headwaters. The summer temperature averages 58° at the eastern end of the basin and 65° at the western end.

The Machias basin, one of the three principal river basins in this area, is about 50 miles long and 18 miles wide. The watershed area is about 495 square miles. The basin has numerous small ponds and lakes, whose total area amounts to 25 square miles, or 5% of the basin area. The Machias river rises in the Machias Lake system and flows southeasterly for about 50 miles before reaching tidewater at Machias, at the head of Machias Bay. The river runs through undeveloped forest for practically its entire course.

The East Machias River basin adjoins the Machias basin on the northeast. The river has its headwaters a short distance to the southeast of Grand Lake, in the St. Croix system. Its course is nearly parallel to that of the Machias. The river flows into Machias Bay at East Machias, three miles east of the mouth of the Machias River. The area drained by the river is about 289 square miles. Among the numerous lakes in the river system are Crawford, Hadley and Gardner Lakes.

The Union River basin, adjoining the lower portion of the Penobscot basin, is about 40 miles long and 18 wide. The river is formed at a point about 15 miles above its mouth by the confluence of the East and West branches, which are, respectively, 25 and 35 miles long. The river drains an area of 496 square miles including some 54 square miles of lake and pond area which represents 10.9% of the basin area, a percentage exceeded nowhere in Maine except by the 13.1% water area on the Presumpscot River. The Union river is tidal from Ellsworth to Blue Hill Bay.

Discharge records of the Machias and East Machias Rivers are kept by the U. S. Geological Survey in cooperation with the state of Maine. Detailed data for these stations can be found in the U. S. Geological Survey Water Supply Papers, Part I -- North Atlantic Slope Basins. Table III-A contains certain data for these stations as summarized from unpublished records in the office of the District Engineer at Augusta and from the published Papers of the Survey.

The hydrograph on Chart 2 shows the average monthly runoff at Whitneyville over a period of 10 years. The average monthly runoff for this period is 2.14 cubic feet per square mile from a drainage area of 465 square miles.

HUMAN OCCUPANCY

Population The population of these coastal basins in 1930 was approximately 50,000, about 3000 less than in 1920. The population density in this distinctively rural and wilderness section is only about 20 per square mile. The settled areas comprise only the coast, the eastern section bordering Passamaquoddy Bay and the western section adjacent to Penobscot Bay.

The five sizable communities of the region range from 2000 to 4500 in population; of these, Bar Harbor is the largest because of its importance as a summer resort. Among the remaining towns, under 2000, many of them are hamlets with less than 100 population, and some are actually uninhabited.

The population of the two counties in which this district lies has dropped in almost every decade since 1890. In the decade between 1920 and 1930 Washington County lost almost 10%, while in the same period Maine as a whole gained nearly 4%. The gains and losses of towns are shown on Map 7. Of the eight largest towns, six declined in population between 1920 and 1930, and the only two that gained, Bar Harbor and Mt. Desert, owed their increase to the fact that they are primarily summer resorts. Unless present industries are expanded or new ones established, it is probable that this area will continue to lose population.

Agriculture Only a fifth of the land in these basins is in farms; of the total farm area, three-fourths is pasture and woodlot, and less than one-fourth is in crops. The soil is low in fertility and generally unsuited to the production of tilled crops. The average value of farm land is about two-thirds that of farmland in the state as a whole. Although there is a limited amount of general farming, the principal source of revenue in the eastern area is the blueberry crop, which accounts for all or the greater part of farm incomes. This industry has developed rapidly in the last fifteen years. The woodlot is the only other important source of cash income derived from farming.

Basic conditions for farming are so unfavorable that parts of this region constitute a problem area. One of the reasons for this condition is that lumbering was originally the principal activity, with incidental farming on a subsistence basis. When the lumber supply was exhausted there was a decided decrease in population, and the farmers were left with no near-by market for their products. The result has been a continuous decline in farm activities and in the prosperity of the entire region.

The improvement in agricultural conditions is apparently dependent on the degree to which farmers adopt such procedures as may be recommended on the basis of the survey of rural conditions made in 1935.

Industry Industrial work in these basins is confined to lumbering, stone-quarrying and the operation of canneries. The canning of blueberries and sea foods is probably the most important activity and the principal source of industrial income.

Mining The principal product is granite, which is quarried in several locations. The existence of a silver-lead-pyrites belt in this section has led to the spasmodic operation of several mines, principally for the extraction of lead, but none of these mines has been developed to the point of successful commercial production. There is little likelihood that production will ever become commercially successful, although the apparent value of mineral deposits is such as to warrant further investigation.

Lumbering A large part of this territory is wild forest, primarily spruce, fir, white pine and hardwoods. The principal product is pulpwood, with a comparatively small amount of white pine and cedar logs. Production is limited, however, as conditions are not favorable for the establishment of pulp mills, and the cuttings have to be taken out over the road to the nearest mills. Lack of suitable transportation facilities and difficulty in regulating and combining the output of small operations to meet market requirements are problems which must be solved before there can be any material increase in the volume of production.

Fishing Fishing was once an important activity at many points along the coast, particularly at Eastport and Lubec. Canning factories for smelt, herring and other fish products have been successfully operated, but due to competition and other factors the market has declined and therefore the local canning industry has suffered.

The fishing industry is dependant on the development of a larger market for the products of canneries, as the remoteness of the region from large markets practically precludes trade in fresh fish in competition with more central ports.

Recreation The wildlands of the basin, extending into the Grand Lake Stream region, attract and, if properly administered, will continue to draw many sportsmen. Some of the more accessible inland waters have been selected as summer home sites, but the most intensive recreational use is concentrated along the ocean front in the western portion of the drainage area, particularly on Mount Desert Island and Penobscot Bay. In the eastern part of the drainage area there are few summer homes, and summer week-end visitors are not many because of the distance from population centers. Since the eastern coast scenery is especially attractive an increase in recreational use will undoubtedly follow the improvement of transportation facilities.

Transportation The coast line from Penobscot Bay eastward to Passamaquoddy Bay at the Canadian border has many inlets and harbors. Bar Harbor, on Frenchman's Bay, can accommodate vessels of moderate draft, while the Bay itself is deep enough and has adequate anchorage for deep sea craft. It is used extensively for yachting by the large summer colony on Mt. Desert.

On Passamaquoddy Bay, Eastport Harbor can accommodate deep draft vessels and Lubec, another fishing port, is open to smaller craft. Both ports are seriously handicapped by the unusually high tides of the bay, which average about 18 feet.

Through Machias harbor and river, Machias is accessible from the ocean to commercial vessels. The channel in the four-mile stretch of Union river between Ellsworth and Blue Hill Bay has not been maintained. The remaining streams are small and not navigable by commercial craft.

The coastal towns and the more thickly settled areas at the western and eastern ends of the district are served by a major state highway and improved feeder roads. Another highway crosses the northern part of these basins, and is connected with the coastal section by a few local roads. The system apparently meets the requirements of the sparse local population, but improvement of the main coastal route east of the Union River is necessary to the expansion of recreational activity in the area.

The coastal section of this area is traversed by the line of the Maine Central Railroad from Bangor to Eastport and Calais. From Ellsworth a branch line runs down to Mt. Desert Ferry to serve the Bar Harbor region.

During the vacation season regular air transport service is maintained at the Bar Harbor airport, at present the only landing field in the area. As air travel from Bangor to Calais and the Maritime Provinces increases, additional emergency landing fields will be needed along this route.

WATER USE AND CONTROL

Pollution The northern part of this area, adjoining the western boundary of the St. Croix basin, lies in the sparsely populated Grand Lake Stream wildlands. The population pattern closely follows the coast in a band ten to fifteen miles wide. Several communities have local sewerage problems, viz., Lubec, Machias, Bar Harbor, Mount Desert, Northeast Harbor, and Ellsworth. Pollution concentrations are infrequent since the discharge of both domestic and industrial wastes is distributed along more than 200 miles of ocean front. Conditions in a few localities need improvement, but financial stresses cause the industries and municipalities to postpone serious consideration of corrective measures.

Throughout the unsettled inland section, fish and game have already proven to be of distinct recreational value. Maintaining the inland waters' present sanitary condition will conserve this value and will attract summer residents.

Water Supply More than 25 public supply systems serve the coastal and inland communities in this area; over half of these rely upon lake or pond sources and nearly one-third draw upon springs. The existing sources of supply clearly illustrate the adequacy of surface and ground water through the entire basin. Several large communities of 300 houses or less--Jonesport and Deer Isle are the largest--should eventually install public supply systems. The delay has been primarily for financial reasons.

Flood Control No flood problems of importance are to be found in this area. In the Machias basin the forests, lakes and ponds prevent quick run-off so that extreme floods are rare. Few economic sites are available for storage reservoirs. The property along the river is of insufficient value to justify the cost of protection. The populated areasof the towns along the river are, in general, located on high ground and away from the river, so that very little damage results during freshet flows.

In the Union River valley natural conditions minimize flood hazards, and present storage is effective in retarding the flood runoff. Owing to the small amount of damage from previous floods and the lack of economical storage reservoir sites, measures for flood control would not be feasible.

Power Existing power developments are to be found on several of the streams in this area. Their total installed capacities amount to 15,714 horsepower, the largest installation being at Ellsworth on the Union River, where the wheel capacity is 11,220 horsepower.

On the Machias River less than one-fifth of the potential power of the river has been developed, and the existing installations are either at or close to tidewater. The largest installation is that of the Bangor Hydro-Electric Company, at Machias, which has an installed capacity of 410 horsepower. There are two other plants on the Machias River: one at Machias, with an installation of 162 horsepower; the other at Whitneyville, with an installation of 330 horsepower.

The most promising undeveloped sites on the Machias are at Great Falls and Holmes Falls, where heads of 20 feet and 40 feet respectively could be developed. The corresponding wheel capacities would be 1000 horsepower and 1890 horsepower. Owing to the small market for power in the valley and the distance from outside markets, the improvement of this river will undoubtedly be delayed for some time.

As the lake and pond storage is mostly in the upper part of the Machias basin, the greater portion of the river receives the benefits of stream regulation. Of the 55 lakes and ponds in this system, the most important are controlled by dams at their outlets. The total water storage is estimated to be 77,000 acre-feet.

At East Machias, on the East Machias River, the Bangor Hydro-Electric Company has an automatic hydro-electric plant with a capacity of 1700 horsepower.

The principal development on the Union River is at Ellsworth, where the Bangor Hydro-Electric Company has an installation of 11,220 horsepower, developed under a head of 60 feet. The only other development of over 100 horsepower capacity on this river is at Ellsworth Falls, where 300 horsepower are developed for manufacturing purposes. Both of these plants are located close to tidewater. Small plants totalling 270 horsepower capacity are located on the tributaries.

The upper portion of the river has never been developed, although there are possibilities for additional small developments which would total about 5000 horsepower. These sites are, however, so scattered along the river that it will be some time before there is any economic justification for their development.

There are numerous lakes and ponds in the Union River basin, the largest of which are located in the lower portion of the watershed. The total area of lakes and ponds is about 54 square miles or 10.9% of the total basin area of 496 square miles. These water bodies, most of which are regulated by dams or sluices at their outlets, provide an estimated storage of about 55,000 acre-feet. In 1922, 144,000 acre-feet of additional storage was developed by the construction of a dam near Brimmers Bridge, a short distance above Ellsworth.

The Passamaquoddy tidal development project is located near Eastport, at the northeastern extremity of this area. Plans call for power generation by the use of a high level pool, about 37 square miles in area, in Cobscook Bay, and by the construction of a series of dams, a filling gate structure, navigation lock and power house. The tidal basin would be kept at or near high tide level and power generated at times when the available head (or difference between basin and sea level) exceeded about $5\frac{1}{2}$ feet. There would be two daily periods of about 5 hours and 25 minutes, or a total of nearly 11 hours daily, when no power would be generated. It is proposed in these periods to supply auxiliary power from a Diesel engine plant or perhaps from some utility system, if available.

The proposed initial installation of five units totalling 62,500 kilowatts under a 20-ft. head, but about 30,000 kilowatts under the average available head of about 12 feet, is estimated to cost about $38,000,000 and to be capable of producing about 261 million kilowatt-hours yearly of primary power costing about 0.92¢ per kilowatt-hour at switchboard.

A 10-unit plant is estimated to cost about $51,700,000 and to be capable of producing about 508 million kilowatt-hours yearly of primary power at a cost of 0.73¢ per kilowatt-hour at switchboard; a 20-unit plant would cost about $81,000,000 and would produce about 876 million kilowatt-hours of primary energy at about 0.69¢ per kilowatt-hour at switchboard.

The hydro plant would have, of itself, no primary power, and reliance would have to be placed on auxiliary power. Since no market existed, it was proposed to develop industrial plants for the manufacture of aluminum and of stainless steel to make use of the power.

The U. S. Engineers commenced the construction of this project in 1935 with an initial allotment of $10,000,000. The amount was later reduced to $7,000,000. Work on the building of dams progressed for about a year but was stopped in the summer of 1936, due to the failure of Congress to appropriate funds for carrying on the work. The plant which had been set up by the Army Engineers was demobilized, and the facilities at the project were turned over to the National Youth Administration.

Navigation There are three waterways in this section for which the War Department Engineers record traffic:--

Waterway	1935 Traffic Tons	Chief Commodity	Controlling Depth Feet
Lubec Channel (1)	18,437	Fish	12
Bar Harbor (2)	11,768	Coal	9
Stonington	48,044	Granite	0-12

(1) Additional 7,876 tons, cargoes in transit
(2) Passenger traffic numbered 6000

The broken coast has many other natural harbors used by fishermen and recreationists. Corea Harbor in the town of Gouldsboro, 12 miles east of Bar Harbor, has been investigated and the Chief of Engineers' Report of 1936 states that funds could be profitably expended in deepening the anchorage basin. Several other waterways in this area have been investigated, or soon will be. In general, where the current use was not judged great enough to warrant present improvement, regional investigation must be made to determine whether improvements are necessary in view of prospects of later use.

Erosion Occasional gullies indicate erosive action along the banks of many of the small rivers and estuaries in this region. The gullying is accompanied by slight sheet erosion.

Drainage Extensive drainage of coastal marshes would destroy their value as natural habitats for waterfowl and other wildlife. It is, however, necessary in order to abate the mosquito nuisance in the marshes near settlements. Seeking to preserve beneficial marshes, local authorities propose limited drainage where the mosquito nuisance is severe. The State Entomologist has suggested that in the Mount Desert Island vicinity approximately 1200 acres be drained, 850 acres in Gouldsboro and 320 in Southwest Harbor, but nowhere else in this coastal basin have projects been recommended for immediate consideration. Drainage may later prove to be of value in reclaiming lands for blueberry culture.

Recreation Although water resources in the eastern Maine coastal basin are vitally linked with the present and future recreational activities, the major recreational problems do not fall in the water resources category, except in the case of fish welfare and water transportation.

PENOBSCOT BASIN

GENERAL DESCRIPTION

The Penobscot, the largest of the Maine basins, has a drainage area of 8570 square miles, more than 25% of the area of the entire state. Of all the New England rivers, only the Connecticut has a larger drainage area. The area of the Penobscot exceeds that of the Kennebec, the third largest, by over 2500 square miles. The basin is about 160 miles long, extending north and south, and has a maximum width of about 115 miles.

The headwaters of the river lie in the mountainous region near the Canadian boundary, the region from which flow also the headwaters of the Kennebec and St. John Rivers. The main river is formed by the junction of the West Branch and East Branch at Medway, 101 miles above the mouth of the river, and 74 miles above the head of tidewater at Bangor. The total distance from the extreme headwaters of the East Branch near the Canadian border to the mouth of the river at Castine is nearly 250 miles. The course of the river from Medway to Bangor takes a generally southerly direction.

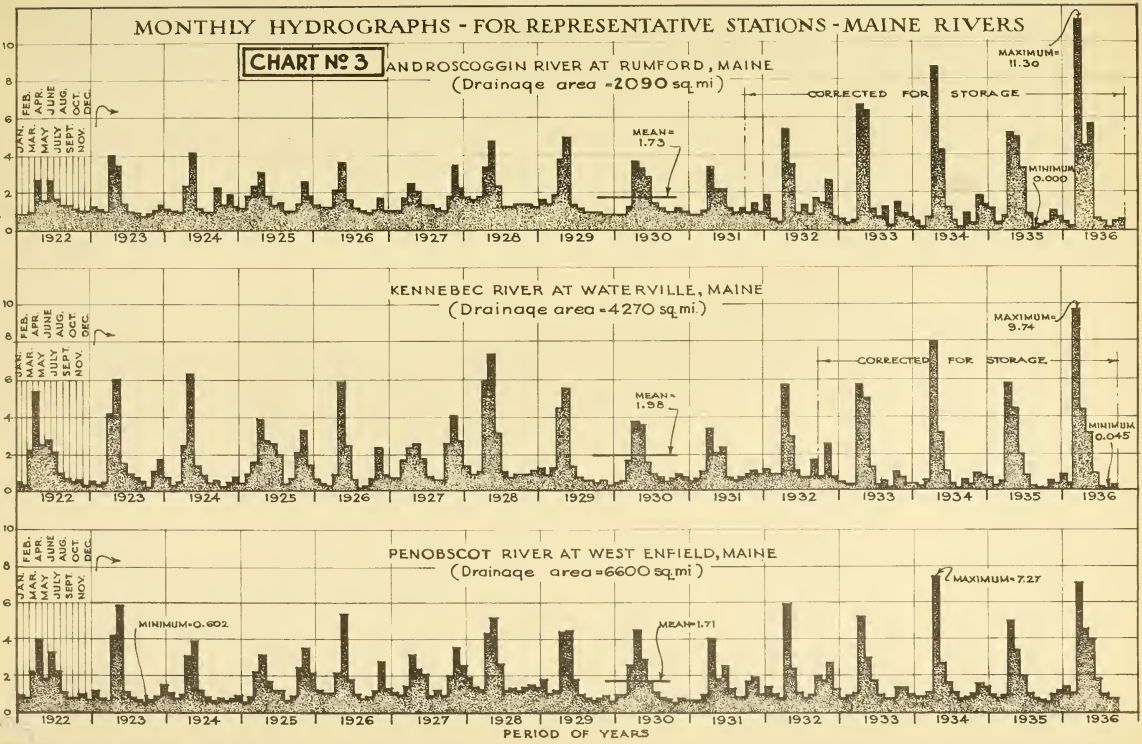
The general elevation of the basin is somewhat less than that of the Kennebec, and its topography is fairly uniform, being much less rugged than the mountainous basins of the Kennebec and Androscoggin. Below Bangor, the country is hilly, with mountains of low elevation. Above Bangor, the topography becomes undulating and, in the region of the headwaters, the country is broken with lakes, swamps, hills and detached mountains. Mt. Katahdin, the highest peak in Maine, with an elevation of 5267 feet, lies between the East and West Branches. The numerous lakes in this basin have a total area of 407 square miles, 4.8% of the total drainage area.

The rock formation is chiefly shale, slate and schists, with some granite formation and occasional deposits of iron and lead pyrite. The soils are mostly sand and gravel, with silt-loam and clay predominating in the agricultural lands along the lower reaches of the main river.

About 90% of the basin is forest land, much of which has been cut over for pulp wood. Less than 5% of the total area is in farm crop land. In the lower part of the basin and in the Piscataquis valley there is extensive cultivation. The northeastern corner of the basin, along the Bangor-Aroostook Railway, is in the Aroostook potato district. The areas to the north and west of Millinocket are forest wilderness.

The mean annual rainfall varies from 37", at the western rim of the basin, to 43" near the mouth of the river, with the average for the basin being about 39". The average summer temperature is 60° on the western rim and 65° near the coast, and the winter temperature varies for these localities between 12° and 22°.

Important tributaries to the Penobscot are the East and West Branches, the Mattawamkeag, and the Piscataquis Rivers.


MONTHLY HYDROGRAPHS - FOR REPRESENTATIVE STATIONS - MAINE RIVERS
CHART No 3
ANDROSCOGGIN RIVER AT RUMFORD, MAINE
(Drainage area = 2090 sq. mi)
MAXIMUM= 11.30
CORRECTED FOR STORAGE
MEAN= 1.73
MINIMUM 0.000
KENNEBEC RIVER AT WATERVILLE, MAINE
(Drainage area = 4270 sq. mi.)
MAXIMUM= 9.74
CORRECTED FOR STORAGE
MEAN= 1.98
MINIMUM 0.045
PENOBSCOT RIVER AT WEST ENFIELD, MAINE
(Drainage area = 6600 sq. mi.)
MAXIMUM= 7.27
MINIMUM= 0.602
MEAN= 1.71
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
DISCHARGE - CUBIC FEET PER SECOND PER SQUARE MILE
0 2 4 6 8 10
1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936
PERIOD OF YEARS

The East Branch rises in northern Piscataquis County and flows east and south about 75 miles to its confluence with the West Branch, at Medway, falling about 800 feet along its course below Chamberlain Lake, at the headwaters. Its drainage area of 1130 square miles includes 240 square miles from which the runoff has been diverted from the Allagash, Chamberlain and Telos Lake district of the St. John basin to increase the flow in the East Branch available for logging operations. The watershed of the East Branch is mostly wooded and has slightly over 5% water area.

The West Branch, formed near the Canadian boundary by the union of two small streams, known as the North and South branches, flows in a generally northeasterly direction in its upper portion, but after passing through Chesuncook Lake, its course for the remainder of the distance is southeast. Its length is about 100 miles. Numerous large lakes are in this basin, including Chesuncook Lake (Ripogenus Reservoir), Twin Lakes and Millinocket Lake. The water area of all the lakes and ponds amounts to over 8% of the basin area of 2100 square miles. The drop in the river below Seboomook Lake, at headwaters, is nearly 800 feet. The steepest fall occurs a short distance below Chesuncook Lake, where the river drops 214 feet in 2.4 miles.

The Mattawamkeag River rises in southern Aroostook and northern Washington Counties and flows southwest about 50 miles to its junction with the Penobscot at Mattawamkeag, about 12 miles below Medway. The principal lake in this area is Baskahegan Lake with a water area of 16.4 square miles. The water area of the several lakes is slightly less than 2% of the entire basin area.

The Piscataquis River rises just south of Moosehead Lake and flows very nearly due east for 75 miles to its junction with the Penobscot at West Enfield. Schoodic and Sebec Lakes are the largest lakes in this basin, each with a water area of 10.9 square miles. These, together with several smaller lakes, comprise 2.3% of the basin area of 1500 square miles.

At numerous stations on the rivers of the Penobscot system discharge records are kept by the U. S. Geological Survey in cooperation with the state of Maine. Detailed data for these stations can be found in the U. S. Geological Survey Water Supply Papers, Part I - North Atlantic Slope Basins. The figures in Table III-A are summarized from unpublished records in the office of the District Engineer at Augusta and from the published Papers of the Survey.

The hydrograph on Chart 3 shows the average monthly runoff during the past 15 years at West Enfield on the Penobscot River. The average runoff from the drainage area of 6600 square miles above West Enfield is 1.77 cubic feet per second per square mile.

HUMAN OCCUPANCY

Population The population of the Penobscot Basin in 1930 was 113,000, a gain of only 1000 over 1920. In the northwestern section, the average density is less than 5 people per square mile; in the more thickly settled southern and eastern regions, including the lower part of the Aroostook farming area, the average density is about 30 per square mile. Most of the population is in the lower Penobscot river valley.

The largest and most important manufacturing and trading center in the basin is Bangor, with a population of 28,749. The other towns of more than 2500 population are:

Old Town	7266
Brewer	6329
Millinocket	5830
Dover-Foxcroft	3750
Orono	3338
Lincoln	2970
Milo	2912

The rural population constitutes about two-thirds of the total.

Between 1900 and 1930 the population increase in Penobscot and Piscataquis counties, which form the greater part of the basin, was slightly greater than the 15.% gain in Maine as a whole. In the last decade of that period, however, the increase in the basin was less than 1%, one-fourth the state rate. Map 7 shows that many towns lost population in the period and that those which had the greatest gains lie for the most part along the main river. In view of past trends and of a predicted growth of less than 10% for the entire state in the next twenty-five years, only a moderate increase in this area may be expected.

Agriculture Farm land covers a small portion, one-eighth, of the watershed, and only two-thirds of that area is tilled land and pasture, the remainder being woodland. Its value per acre (land and buildings, 1935 valuation) is about $23 as against the state average value of $30. The average size of a farm is about 125 acres. Livestock and forest products form important sources of farm income.

Both farm population and the number of farms increased between 1930 and 1935. This trend, common to all New England, is probably due to the decline in manufacturing activity. There is no indication that there will be further increase in farming activity. There are a number of rural problem areas on the borders of forest land, and these have been recommended as subject for further study.

Industry Forests are the basis of industrial development in the watershed. Although the production of timber has drooped to a relatively small amount, forest and water resources are the most valuable assets of the region. Pulp and paper mills and wood-using industries along the Penobscot, particularly at Bangor, employ over half of the 8000 industrial workers of the basin. There are also various small industries, including manufactories of textiles, shoes and machinery. In 1933 the value of products manufactured in the basin, of which pulp and paper formed the greater part, was about 15% of the total value in the state.

The rate of decrease in the value of manufactured products in this basin between 1929 and 1933 was somewhat greater than the rate in the entire state. This may be accounted for by the fact that the pulp and paper industries suffered a severe decline in that period because of competition from outside sources in the production of newsprint. Recovery will be largely dependent on improvement of conditions in the paper industry. Changes involving the manufacture of finer grades of paper than newsprint are being made by some mills.

Mining Iron sulphide and lead-pyrite are found in the central part of the basin. The most successful mining venture was that carried on by the Katahdin Iron Works during the middle of the last century. There are a few small lime, granite and slate quarries now in operation. On the basis of general surveys it is believed that further investigation of the mineralized areas of the northern section of the basin is justified.

Lumbering Intensive lumbering has for more than a century been the most influential factor in the development of the Penobscot basin. Bangor, the center of the industry, at one time claimed to be the world's largest lumber export point. In the past enormous quantities of forest products have been procured from this area. With the depletion of virgin forests and competition from other regions the production of long logs for lumber has steadily declined in this basin and in the entire state, until now about three-fourths of the timber cut in the Penobscot area is pulpwood. The assessed value of pulp and paper mills along the Penobscot in 1934 was about $5,500,000; of the saw mills and lumber, about $1,000,000.

The status of Maine forests and the conditions in the lumber industry indicate that pulpwood will for some time continue to be the principal forest product. The extensive areas of spruce and fir along waterways suitable for log driving have led to, and will continue to justify heavy investment in pulp and paper mills. Increased lumber production will depend on the establishment of more industries manufacturing wood products and on the adoption of modern competitive methods of production and marketing.

Fishing There are no commercial fishing resources in the Penobscot Basin.

Recreation The Penobscot Basin links nearly all types of Maine's recreational attractions. The westerly and northerly tributaries drain a part of the northwestern Maine plateau commonly referred to as "big woods," while the easterly tributaries rise in that part of the wildland region known as Grand Lakes District. Finally the river empties into Penobscot Bay, renowned for its attractive rugged shores and picturesque islands.

In the extensive forest lands of the basin, the water surface of lakes and ponds aggregates over 400 square miles. The diversified recreational possibilities of the basin--hunting and fishing, canoeing, mountain climbing, camping, and touring depend directly upon its water resources.

Transportation The Penobscot River, navigable for the 27 miles from Penobscot Bay to Bangor, has a controlling channel depth of 14 feet at mean low water, a depth sufficient to meet present traffic needs. Above Bangor on the main river and on the tributaries water transportation is limited to the floating of logs to saw mills and pulp mills. This is a major function of the waterways and an indispensalbe feature of the logging industry. The maintenance of stream conditions suitable for log driving has involved heavy investment and is regarded as the prime factor in the development of water resources.

The principal cities and towns of the lower basin are interconnected by an adequate highway network. Except for the main route to the Aroostook region, the northern portion of the watershed is without roads other than those privately built for lumbering operations.

The main line of the Maine Central Railroad from Bangor to the Maritime Provinces runs up the Penobscot valley and thence to Vanceboro in the St. Croix basin. The Penobscot basin is also crossed from north to south by the Bangor and Aroostook Railroad and from east to west by the line of the Canadian Pacific Railway which connects St. John and Montreal. Between Mattawamkeag and Vanceboro, the latter line operates on the Maine Central tracks.

Scheduled air transport service is now provided the year round from Boston to Bangor, and from there to Millinocket and Aroostook County points. In summer this service is extended to include Bar Harbor. Operation on the Trans-Canada airway, which crosses this basin approximately along the line of the Canadian Pacific Railway, is scheduled for the near future. Development of airways from Bangor to Moosehead Lake has been suggested by the Maine State Planning Board. Existing landing fields are located at Bangor, Brownville and Millinocket.

WATER USE AND CONTROL

Pollution A population of about 10,000 discharges sewage into the river at Millinocket, East Millinocket, Lincoln, Howland, Old Town and Orono, while nearly 35,000 people in Bangor and Brewer add to the domestic wastes in the Penobscot at the head of tidewater. Probably the most deleterious industrial wastes entering the river are from pulp and paper mills, of which nine employ 3500 persons, although eight woolen mills with 1300 workers, four fertilizer plants, and fifteen creamery, ice cream or pasteurization plants discharge wastes which contaminate the river.

In a study of Maine rivers made in 1930 bacterial concentration was shown to be about 1000 per 100 cc in the Penobscot from Millinocket to Old Town. From here to below tidewater there was a substantial increase. Pollution is so great as to make necessary filtration of the water supplies for Millinocket, Old Town and Bangor. The 1930 study shows that in a stretch of the river below Millinocket the discharge of untreated pulp and paper wastes reduces the dissolved oxygen content and destroys the plankton (a source of fish food) so that fish life is endangered. The importance of the fishing grounds tributary to the main stream is such that the effect of mixed wastes on fish food, life and migration is so serious as to require remedial measures. The points at which domestic and industrial wastes empty into the river are listed in Table IV-A.

There is a point at which it is no longer economical to purify water for potable use; this point has apparently been reached with reference to the river near Bangor. The remedy is purification of domestic and industrial wastes before discharge into the river at Orono and Old Town; the treatment of Bangor sewage is also desirable. Partial treatment of industrial wastes above Old Town is needed to reduce the biochemical oxygen demand.

Public health and industrial authorities, although fully aware of the sanitary problem, have believed it untimely to press correction measures, in view of the inability of local industries and municipalities to assume large financial responsibilities.

Although the treatment of polluting matter places a financial burden on municipalities and industry, recognition must be made of the direct income derived from the transient population which uses these areas for various recreational purposes. Since this use will continue only so long as the natural advantages are unimpaired, considerable financial outlay is warranted.

The first attack upon the Penobscot pollution problem should be a complete sanitary survey of the principal streams, lakes and ponds. After collecting information concerning the degree and sources of contamination throughout the basin, it will be necessary to select practical methods of reducing pollution to the lowest degree economically justifiable.

Water Supply The towns served by organized water systems contain 51% of the total basin population of 155,500. The majority of these systems are semi-public; have surface water sources; and employ sand filtration or chlorination, or a combination of both. Bangor, with a population of 28,749 gets its drinking water from the polluted Penobscot River and hence is forced to subject the water to thorough treatment. The bacterial load on the purification plant is high on account of the enormous quantity of organic industrial waste which must be removed. The next largest supply, that of the Penobscot Water Company, serves Brewer, Orono and Veazie. It is taken from Chemo Pond and is physically unsatisfactory because of periodical high color and taste. Old Town uses filtered and chlorinated water taker from the lower reaches of the Penobscot River.

The larger towns not supplied from a central source are listed as follows:

Howland	1605	Corinth	931
Hermon	1204	Orland	891
Orrington	1167	Carmel	881
Enfield	1138	Exeter	773

Some two dozen communities warrant attention in addition to those listed above. New supplies can be developed as needed from ground and surface sources in the basin. Table V-A gives the water supply statistics for the basin.

Flood Control Floods in this basin are caused principally by the combination of heavy rainfall and melting snow. About 55% of the floods of high discharge peaks and practically all of the highest peaks on the river have occurred in March, April or May. The flood of 1936, with a peak of 125,000 cubic feet per second at West Enfield, was second only to the flood of May, 1923, when there was recorded a peak flow of 153,000 cubic feet per second, equivalent to a unit discharge of 23.18 cubic feet per second per square mile.

The flood of 1936 caused an appraised damage of $369,000 and the flood of 1923 caused an estimated damage of $1,300,000. The Engineers estimated the probable annual damage on the river to be about $55,000.

Over most of its length the river has been confined to its course during the past floods, by reason of its steep banks. There is, however, frequent overflow of the banks in low sections, but the damages here have been small because so much of the land flooded is forest-covered and swamp area.

Ice jams often cause the water to back up to such heights that it overflows the banks. This jamming is usually caused by bridge piers and other structures which interfere with the flow of the river.

A number of flood reservoir sites have been investigated by the Engineers, but no recommendations are available as to whether or not these sites are feasible. In view of the low annual damage the probabilities are that there is no immediate need for flood control reservoirs.

As is true on other rivers in Maine, even though the economic feasibility of flood control reservoirs cannot be established at present, it would be well for communities along the river to remove obstructions which cause ice jams and build future structures higher than the previously observed high water levels.

Power The estimated available power on the Penobscot and its tributaries, amounting to 377,063 horsepower, exceeds that on the Androscoggin by 7% and that on the Kennebec by 8%. Fully 135,000 horsepower is developed at existing plants of 100 horsepower capacity or more, most of which are located in the middle and lower portions of the basin. The largest total developed power on any one stream is that on the West Branch, in the amount of 85,638 horsepower. Here is the largest individual installation in the basin, the Millinocket plant of the Great Northern Paper Company, with 42,500 horsepower capacity. On the main river, 41,109 horsepower are developed and on the tributaries, other than the West Branch, 8,351 horsepower.

The existing power of the Penobscot basin is developed almost entirely for pulp and paper manufacture and for public utilities. Four-fifths of the public utility power in the Basin is controlled by the Bangor Hydro-Electric Company, which is interconnected with power systems in adjacent districts.

Although there is still much undeveloped power on the rivers, particularly on the main river and on the East and West Branches, there is at present small demand for additional power. Many of the undeveloped sites would be too small for economic hydroelectric power installations, and the larger sites are too far from markets to make their development economically feasible.

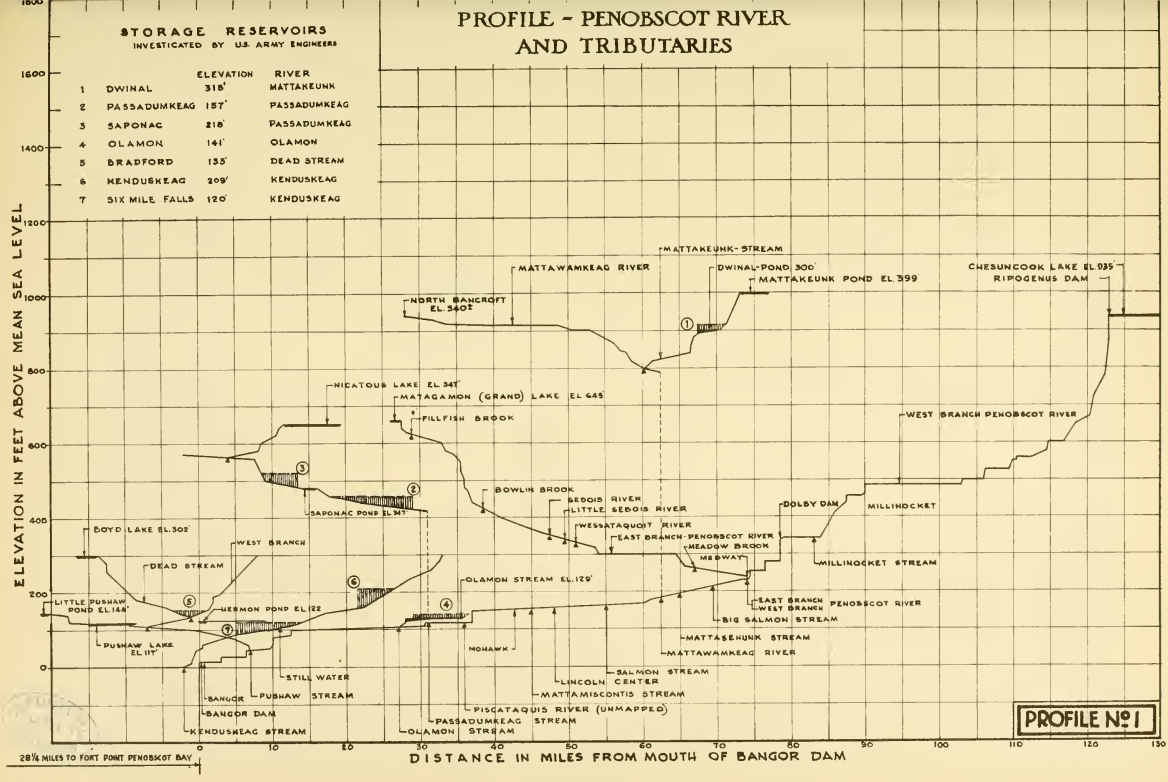
Possibilities exist for increasing the power at partially developed sites and at sites where present installations are more or less obsolete. However, any increase in the power output at these sites will undoubtedly be deferred until the economic situation requires it.

The present developments of 1000 horsepower or over on the main river and the tributaries as listed in the office of the U. S. G. S. District Engineer at Augusta as of January 1, 1937, are given below:--

PROFILE - PENOBSCOT RIVER AND TRIBUTARIES

STORAGE RESERVOIRS
INVESTIGATED BY U.S. ARMY ENGINEERS

		ELEVATION	RIVER
1	DWINAL	318'	MATTAKEUNK
2	PASSADUMKEAG	157'	PASSADUMKEAG
3	SAPONAC	218'	PASSADUMKEAG
4	OLAMON	141'	OLAMON
5	BRADFORD	135'	DEAD STREAM
6	KENDUSKEAG	209'	KENDUSKEAG
7	SIX MILE FALLS	120'	KENDUSKEAG



PROFILE No. 1

EXISTING PLANTS ON PENOBSCOT RIVER OF 1000 OR OVER INSTALLED CAPACITY

River	Location or Plant	Wheel Capacity H. P.
Penobscot River	Bangor	2,460
Penobscot River	Veazie	8,461
Stillwater Branch	Orono	3,500
Stillwater Branch	Stillwater	2,660
Penobscot River	Great Works	9,658
Penobscot River	Nekonegan	2,170
Penobscot River	Milford	7,000
Penobscot River	West Enfield	4,900
West Branch	Medway	5,000
West Branch	East Millinocket	9,888
West Branch	Dolby	18,900
West Branch	Millinocket	42,500
Twin Lakes	North Twin Dam	9,350
Piscataquis River	Howland	3,000
Sebec River	Sebec	1,338

These plants account for 130,785 horsepower; in addition, 4313 horsepower is developed at 15 plants with installations ranging from 100 to 850 horsepower.

The undeveloped power is estimated at 241,965. Of the possible sites the following were described by the U. S. Army Engineers in House Document #652, 71st Congress, 3rd Session as those having the most economic promise:--

POWER AT UNDEVELOPED SITES

Location	Drainage Area-Sq.Mi.	Head Ft.	Wheel Capacity (HP) Flow Available 50% of time	Flow available 90% of time
Basin Mills	7,710	14	11,380	6,880
Marsh Island	7,480	17	10,200	6,150
Gilman Falls on Stillwater Branch	7,380	10	1,580	1,130
Spencer Rapids	7,150	20	15,090	9,100
Mohawk Rapids	5,040	16	8,500	5,140
Five Islands	4,860	15	7,960	4,640
Mattaseunk	3,300	46	16,020	9,660
		Total	70,460	42,700

The existing storage on the Penobscot River above Bangor amounts to about 1,926,000 acre-feet, a volume 50% greater than is available on any other river in the state. The lakes and ponds containing this storage have a total water surface of 407 square miles, or 5.2% of the drainage area above tide-water. Three-fourths of the storage, or 1,500,000 acre-feet, is on the East and West Branches.

The most important storage developments are on the West Branch. The Ripogenus and Twin Lakes reservoirs, which contain a little over a million acre-feet, benefit installations of 85,000 horsepower on the West Branch and 41,000 horsepower on the main river. This combined power represents 93% of the total installations in the watershed.

Opportunities for additional storage lie in raising the water levels of existing lakes and ponds. Since the shores of most of these are undeveloped, the resulting flowage of adjacent lands would not cause serious damage.

The following summarization of existing and possible storage, by basins, is taken from House Document #652, 71st Congress, 3rd Session:--

Basin	Storage Existing in 1926 Acre-Feet	Estimated Possible Increase Acre-Feet	Estimated Possible Total Acre-Feet
East Branch	211,000	130,000	341,000
West Branch	1,280,000	39,000	1,319,000
Main River	14,000	151,000	165,000
Mattawamkeag River	89,000	399,000	488,000
Piscataquis River	217,000	217,000	434,000
Passadumkeag River	115,000	64,000	179,000
Total	1,926,000	1,000,000	2,926,000

Navigation The mean tidal range of 13 feet in the Penobscot at Bangor aids in the maintenance of a navigation season which averages nine months out of each year. In 1935 traffic consisted of 11,734 passengers and 680,426 tons of freight. Petroleum products constituted the principal items of commerce. Since no dredging has been done since 1913, there is need of maintenance work in the near future to preserve the existing channel, but there appears to be no need for expansion of the existing navigation facilities at present.

Erosion Except for a large sheet erosion area in the Patten-Island Falls district, the basin has no erosion problems except along the lower reaches of the Penobscot. Moderate sheet erosion has occurred over an area of one to two hundred square miles, principally in the vicinity of Bangor and along tributary river bottom lands.

Drainage The settlements of the Penobscot basin are concentrated in areas relatively free from bogs or swamps. In certain locations, however, the mosquito nuisance may warrant drainage of small areas to secure greater freedom from the pest. Throughout the thinly populated portions of the watershed drainage would seriously accelerate run-off, and disturb wildlife and forest types, causing damages greater than the benefits gained. Extensive drainage can be undertaken only when complete knowledge of potential and desirable land uses has been assembled.

Recreation Except along the main streams, the chief recreational problems, most of which are closely related to water resources, are conservation of existing assets and the encouragement of their use. In investigation of the water bodies and streams there must be continual consideration of the present and future opportunities for recreation and wildlife uses.

CENTRAL MAINE COASTAL BASINS

GENERAL DESCRIPTION

The coastal region lying between Penobscot Bay and the mouth of the Kennebec River is drained by a number of small streams, of which the two largest are the Sheepscot and the St. George Rivers. Each of these drains about one-third of the total area of 850 square miles.

The region is hilly with altitudes ranging from sea level to 900 feet elevation in the northern portion. Near Camden, on Penobscot Bay, there is a group of mountains which have an extreme altitude of 1350 feet. The area is dotted with lakes, ponds and swamps.

The bedrock within the basin is chiefly granite, felsite and quartzite. The soil is generally clay or silt-loam and has been used extensively for agriculture in the past. Nearly 40% of the region is in cleared farm land, the remaining 60% being in scattered woodlands, mostly on farms or summer estates.

The average rainfall over this coastal area is 44 to 46 inches, fairly evenly distributed throughout the year. The average temperature is about 66° in the summer and about 23° in winter.

The Sheepscot River rises in the extreme northwest portion of the basin near Freedom and Albion and flows a little west of south for 30 miles to tidewater at Wiscasset. It drains an area of 238 square miles.

The St. George River rises in the extreme northern portion of the basin and flows south for 30 miles before reaching tidewater. Below Thomaston, the river is a tidal estuary for a distance of 10 miles. The area drained by the river is 225 square miles.

Other rivers in the region are the Medomak, Damariscotta, Passagassawakeag, Megunticook and Goose Rivers.

No stream flow records are kept on the streams in this basin.

HUMAN OCCUPANCY

Population This group of coastal basins extending from the Penobscot to the Kennebec River contained in 1930 about 56,000 inhabitants, practically the same number as in 1920. In contrast to the adjoining Kennebec Basin, which has a large wilderness area and a density of only 25 per square mile, this coast region has a density of about 66 per square mile. A large influx of visitors adds materially to the population in summer.

Small villages and scattered populations predominate; in fact, only three towns have more than 2500 inhabitants:

Rockland	9075
Belfast	4993
Camden	3606

These three communities are primarily trading centers for the surrounding territory, although they have a few manufacturing plants.

There was practically no population growth between 1920 and 1930. Of the larger towns, Camden and Rockland increased in size and Belfast showed a slight decrease. The majority of communities lost population consistently in each decade between 1900 and 1930. Future growth will probably be in the larger towns and will be governed by the amount of manufacturing and by the extent of the summer resident and tourist trade. The latter has a marked influence on many of the coastal communities and supplies a large part of the tax revenue.

Agriculture The size of the average farm in this district is slightly less than the state average of 119 acres, and the acreage value is about three-fourths that for the entire state. The soil is of poor quality and the northern section of the basin is classed as a rural problem area. Although in general crop farming is not successful, poultry raising is a widespread and gainful occupation. It constitutes the source of over one-third of the total farm revenue; likewise, dairy and woodlot products account for appreciable parts of farm income.

Soil conditions and location confine most of the agricultural development to raising livestock, especially poultry. Western competition has forced the adoption of scientific methods in poultry farming in this coastal region, and, because the region has such easy access to Boston, the largest New England market, it is likely that poultry raising will continue to be its most profitable farming activity.

Industry This section is not active industrially. The few small manufacturing plants include among their products lumber, textiles, shoes, canned fish and vegetables. At Rockland there is a lime plant and at Thomaston the largest cement mill in New England. Several of the coast towns have shipyards for the manufacture of small pleasure boats. The total number of industrial wage earners in 1933 was about 2100, and the value of manufactured products about $7,000,000.

The best opportunities for growth in the manufacturing field appear to lie in industries using native raw materials. The lime products industry, an outstanding example, is suitably located with respect to basic materials and water transportation. The canning of sea foods, which is now active on a limited scale, has possibilities for expansion, as have, to a lesser degree, the wood-using industries.

Mining · The mining operations of this region have been at times the most successful in Maine. Extensive lime deposits near Rockland supply material for a lime plant and for the Thomaston cement plant. There are also in this vicinity granite quarries that were once very active. These quarries constitute a valuable asset because of their location on the coast where water transportation is easily available, but their future success will depend upon the demands of the construction industry.

Lumbering Although over half of this area is wooded, it contains no wild lands or extensive forests. Along the coast there is spruce and fir, and inland, hardwood growth with some white pine. There is some long-log production, principally at portable mills, and also a little pulpwood. Timber is taken out over the road as the streams are too small for log driving.

The general character of the woodland of this section precludes any substantial development in lumbering. Operations of moderate size for the production of pulpwood and long logs will probably be maintained, and farm woodlots will continue to be a source of cash income.

Fishing Shipbuilding and fishing were the original industries on this coast, and the latter is still important. Shell fish are taken in large quantities and canned at local factories, but most other fresh fish are shipped to eastern markets.

Ready access to the Boston market and availability of large supplies of fish are elements favorable to the growth of the fishing industry. Local canneries now furnish employment for many inhabitants, and efforts are being made by state authorities to expand this industry by reaching a greater buying public through advertising.

Recreation Wildlife and fish, numerous in this coastal basin, include such species as moose, deer, fox, and various types of water fowl and game fish. The recreational industry is the outstanding seasonal business and, through large numbers of visitors, contributes substantially to the economic life of this region. The extensive tidal reaches that break up the shore line provide excellent coastal scenery and ideal settings for aquatic sports. Inland recreation and wildlife areas, now being developed at Camden by the National Park Service and at Montville and Liberty by the Resettlement Administration, offer exceptional attractions to summer residents and tourists. The Camden area is an admirable site for a state park, while the lake and semi-mountainous area in Montville and Liberty is good for hunting and fishing.

Transportation With the exception of tidal estuaries, there are no navigable waterways in this coastal area. There are many fine harbors, particularly those at Boothbay Harbor, Rockland, Belfast and Searsport, which accommodate coastwise passenger and freight vessels of moderate size. Searsport handles the greatest amount of traffic, 521,124 tons in 1935; Rockland, ranking second, handled 162,961 tons. Coal is the principal commodity of coastwise commerce.

The most important centers of this coastal section, Rockland, Camden, Belfast, lie on the Atlantic Coast Highway, by which they are linked to Bangor on the north and to Portland on the south. A network of secondary roads branches from this major highway to coastal and inland points. Improvement in design and location of the Coastal Highway has been recommended by the Maine State Planning Board and the New England Regional Planning Commission.

Railroad service is provided in the southern section of this area by a branch of the Maine Central Railroad running from Brunswick to Rockland, and additional service by a line running from Belfast to the main line between Portland and Bangor. Freight service from Searsport to Bangor and Aroostook County points is maintained by the Bangor and Aroostook Railroad. Highway bus service is maintained on U. S. Route #1 from Bath to Bangor and on a secondary route from Rockland to Augusta.

The airport at Rockland is the only landing field in the area. By reason of the irregular coast line with its many sheltered harbors the region is adapted to seaplane operations, facilities for which are provided at Rockland and Boothbay Harbor. From Rockland regular seaplane service is furnished to the Penobscot Bay islands during the summer vacation season.

WATER USE AND CONTROL

Pollution The half-dozen municipalities exceeding 2000 population in this basin adjoin bays or tidal estuaries into which they discharge their domestic sewage. The trade wastes from these communities, although widely distributed, add to the load imposed upon the coastal waters in a region which boasts of, and to a great degree subsists upon, the large volume of its recreational business. The sewage systems at Rockland and Yarmouth are known to be inadequate. Inland communities discharge their domestic and industrial wastes into lakes and streams which are in some instances too small for adequate dilution. This practice in waste disposal undermines the recreational values, but careful investigation will be required to determine where such losses are sufficiently great to warrant the installation of treatment plants. Consideration should be given to a survey of the coastal pollution conditions and their probable effect on recreational uses.

Water Supply With few exceptions the domestic and industrial water supplies are adequate for present needs. There are, however, several small coast communities, of which Tenants Harbor, with about 300 houses, is the largest where there are no public water supplies. Such deficiencies are due to lack of funds rather than to lack of available sources of supply. The established public supply systems in the basin number more than two dozen and serve all concentrated communities of over 300 houses. For over half the communities lakes or ponds are the sources of supply, while most of the rest depend on ground water sources.

Flood Control The streams are so small that no great damage results from freshet conditions. Local improvements at points where the flow of streams is restricted would be the most feasible method of preventing the inconveniences and minor losses occasioned by extreme high water.

Power Little opportunity exists for water power development on the streams of this area because their drainage areas are small and their slopes gradual. At present there are 15 plants with a total installed capacity of 3418 horsepower. The individual installations range from 100 to 700 horsepower; the largest is the Damariscotta Mills plant at the outlet of Damariscotta Lake. The Goose River, with installations of 650 and 223 horsepower at Belfast, produces the greatest total power of any of these coastal streams. Three plants at Camden on the Megunticook River have a combined wheel capacity of 674 horsepower.

About 50,000 acre-feet of storage are at present available on the Goose, Megunticook, St. George, Damariscotta and Sheepscot Rivers. The 1912 report of the Maine State Water Storage Commission listed a possible increase in storage of 120,000 acre-feet, over half of which would be on the St. George and Sheepscot Rivers.

About 2000 horsepower has been estimated as possible for new power developments, but it is not likely that such developments will be made in the near future.

Navigation The tidal estuaries in this stretch of the Maine coast between the Kennebec and Penobscot rivers are, in general, adequate to meet the needs of navigation for trade and pleasure. Channel improvements have been made on the Medomak River at Waldoboro and on the St. George River at Thomaston. No further improvements in navigation facilities appear to be necessary.

Erosion Erosion conditions are similar to those along the eastern Maine coast, but erosion itself has reached a more advanced stage. Although erosion creates serious land use problems, it has little effect on water resources problems.

Drainage Consideration has been given to the conflicting factors that affect the desirability of draining swamp areas in the Central Maine Coastal basin. The mosquito pest spoils the attractiveness of any area for recreational use. Coastal marshes provide ideal breeding sites for mosquitoes but, on the other hand, they shelter fish, game and waterfowl, which constitute a definite recreational asset. Recognizing this paradox, state authorities are disposed to proceed cautiously by draining only those marshes adjoining settlements where abatement of the mosquito nuisance will justify disruption of aquatic and semi-aquatic wildlife. The only drainage project recommended in this region at present is that on the 200 acres along the Damariscotta River in Newcastle.

Recreation The probable lowering of recreational values by water pollution assumes first place among the water resources problems of the area. Although pollution is not yet, and probably never will be, sufficiently concentrated to menace health, it is already a serious threat to the recreational industry because it kills fish life and destroys the aesthetic charm of the whole region. The second problem arises from the fact that the changing of water levels would, with few exceptions, prove to be deleterious to wildlife and recreational values.

KENNEBEC BASIN

GENERAL DESCRIPTION

The Kennebec basin, the third largest in Maine, has a drainage area of 5970 square miles, extending north and south about 150 miles, east and west 80 miles. A 60-mile stretch of the basin divide constitutes the boundary line between Maine and the Province of Quebec.

The headwaters are in the high plateau of northwestern Maine, about 2000 feet above sea level. These headwaters are tributary to Moosehead, the largest lake in New England. The main river flows out of Moosehead and follows a southerly course of 120 miles to Augusta at the head of tidewater; from here it continues, as a tidal river, 44 miles to Merrymeeting Bay, where it is joined by the Androscoggin River. The combined waters empty into the Atlantic Ocean at a point about 25 miles east of Portland.

In its upper half the Kennebec basin has a generally high altitude, with numerous peaks of 3000 to 4000 feet. In the lower half the topography becomes hilly and rolling. Lakes and ponds abound in the basin, aggregating a water surface of over 300 square miles, more than a third of which is accounted for by Moosehead Lake.

The rock formation is mostly granite, with some sedimentary deposits, such as slate and sandstone. The whole area is typically of glacial origin, as characterized by its irregular topography and the overburden of glacial sand and gravel with some sandy loams and clay. Little of the area has good agricultural soil. About 12% of the area is in cleared land and 85% in woodland, from much of which the trees have been removed for wood pulp.

The average rainfall in the northern part of the basin is about 36 inches, with the summer precipitation exceeding slightly that of the winter. At the lower end of the basin the annual rainfall is about 46 inches, well distributed throughout the year. For the basin as a whole the annual rainfall averages about 40 inches. Summer temperatures vary with the latitude, ranging from 66° to 61°. The winter average temperature is from 24° to 13°.

The principal tributaries are the Moose, Dead, Sandy and Sebasticook Rivers.

Moose River, the principal feeder to Moosehead Lake, drains the northern portion of the Kennebec basin. Its drainage area at a point about 3 miles above Moosehead Lake is 708 square miles. Between its source and Moosehead Lake it flows through four large bodies of water--Attean Pond, Wood Pond, Long Pond and Brassua Lake. The combined water surface area of these ponds and lakes is 27.4 square miles. At the outlet of Moosehead Lake the drainage area is 1240 square miles, and above this point the total water surface is 155 square miles, or 12½% of the total area.

Dead River rises in the northwestern part of the basin just south of the headwaters of the Moose River and flows easterly through rugged country to join Kennebec at The Forks, about 25 miles below the outlet of Moosehead Lake. Its drainage area of 878 square miles includes 19 square miles of water surface. Spencer Pond, the largest single water body, has an area of 2.6 square miles.

Sandy River rises in the Blue Mountains a few miles east of the Rangeley Lakes, the headwaters of the Androscoggin. The river flows southeast for about 30 miles and then northeast for 20 miles, joining the Kennebec at Skowhegan, above which point the drainage area is 644 square miles. The principal water bodies in the Sandy River system are the Chesterville Ponds and Wilton Pond, which have a combined water surface of 3.3 square miles. The total lake and pond surface is about 6 square miles.

The Sebasticook River, the largest eastern tributary of the Kennebec, rises in the east central part of the basin south of the Piscataquis River in the Penobscot basin. Flowing south and southwest to join the Kennebec just below Waterville, this tributary drains an area of 975 square miles. The several lakes and ponds in the system, including Sebasticook Lake, China Lake, Moose Pond and Twenty-five Mile Pond, have a total water area of 36 square miles.

Other smaller tributaries which join the Kennebec from the west are: Carrabassett River, which drains an area of 340 square miles before entering the main river at North Anson; Messalonskee Stream, which enters the Kennebec at Waterville after draining an area of 205 square miles, 15% of which is water area; Cobbossecontee River, which enters the Kennebec at Gardiner, below the head of tidewater, after draining 220 square miles, nearly 10% of which is water surface.

The U. S. Geological Survey in cooperation with the state of Maine records stream flow at several points on the main river and its various tributaries. Detailed data for these stations can be found in the U. S. Geological Survey Water Supply Papers, Part I - North Atlantic Slope Basins. The figures in Table III-A are summarized from unpublished records in the office of the District Engineer at Augusta and from the published Papers of the Survey.

The hydrograph on Chart 3 shows the average monthly runoff during the past 15 years at Waterville, on the Kennebec. Over this period the average yearly runoff from the drainage area of 4270 square miles was 1.66 cubic feet per second per square mile.

HUMAN OCCUPANCY

Population The population of the Kennebec basin in 1930 was 150,000, about one-fifth of the total population of Maine. This represents a gain of about 2.5% over 1920, slightly less than that of the entire state. The average density of the entire area is only 25 per square mile, although there is a greater concentration than this in the lower part of the basin.

The two principal cities are Augusta, the state capital, with a population of 17,198, and Waterville, 15,454. About two-fifths of the entire population is classed as urban. Cities and towns of over 5000 inhabitants are:

Augusta	17,198
Waterville	15,454
Bath	9,110
Skowhegan	6,433
Gardiner	5,609
Fairfield	5,132

There are eight towns of between 2500 and 5000 population.

Of the fourteen towns having over 2500 population only three showed a loss between 1920 and 1930. The heaviest loss was in Bath, where the population decreased by 38%. This was due to the fact that the ship building industry, on which the town depends for its existence, was inactive during that ten-year period. In the last few years there has been a renewal of that industry and a corresponding increase in population.

Population gains in general were in towns along the lower main river and its tributary, the Sebasticook. (See Map 7.) Losses occurred in many outlying towns, particularly along the western border of the basin. Trends will probably be governed by the condition of the principal industries. If present indications are borne out there will be a slow growth of the industrial communities in the coming decade.

Agriculture Agriculture is widely practiced in the lower part of the basin. The valley farmland is rather fertile, although less so than in some parts of the state, as is indicated by the average acre value of $29.00 (land and buildings, 1930) in contrast to the state average value of $42.00. Farm income is derived principally from dairy and poultry products, field and orchard crops, and woodlot products. The latter account for about 12% of the total farm revenue, which amounted in 1930 to approximately $11,000,000.

Farming in this basin is handicapped by lack of near-by markets, so essential to the specialized farming which is a feature of the agricultural trend. When there were large lumber communities along the edges of the forest lands, the soil, poor as it was, produced enough food to meet the demands of these local markets. Today these sections are rural problem areas because of the decline in the local demand and the inadequacy of means of transportation to distant markets. The only evidences of change in the farming situation lie in the tendency to abandon farms in the problem areas and the trend toward specialization of crops in areas that are suited to farming.

Industry The principal manufacturing centers - Augusta, Waterville and Bath - are on the main river. In 1933 the entire region produced about $43,000,000 worth of manufactures, about one-fifth of the state production. Textiles, boots and shoes, pulp and paper, canned vegetables and lumber are the chief products. Augusta has diversified industries in addition to its principal line -- textiles and shoes; it is also an important trading center. Waterville, primarily a paper manufacturing city, is also a trading center. Bath, near the mouth of the river, is a ship-building town the prosperity of which varies with the activity of that industry.

Between 1929 and 1933 the decrease in the value of manufactured products in this region and in the state as a whole was about the same. Future progress will depend largely upon the degree of activity of the principal industries. There is, however, a tendency toward diversification of manufacturing, which contributes to industrial stability and which is being encouraged by state and local development agencies.

Mining Slate quarries in the northern part of the basin are now in operation, but granite quarries, once active, are now worked but little. At one time tin was commercially mined near Winslow. Since there are no known tin deposits elsewhere in the United States, it is possible that resumption of mining at this point would be profitable.

Lumbering The northern half of the basin comprises a large part of the extensive spruce and fir lands of the state. The Kennebec and its tributaries provide means for floating logs from this area to mills located down stream. As these mills are within easy reach of markets by rail or water, lumbering in this basin is carried on to better advantage than in those basins farther east. The timber cut, principally pulpwood, amounted in 1933 to about 12,500,000 board feet; in the following year to about 30,000,000 feet. In addition to pulp and paper mills there are several wood-using industries, including spool mills and box factories, in the lower part of the basin.

As the principal forest product in the Kennebec basin is pulpwood, the lumbering industry is dependent largely upon activity in the field of paper manufacture. There is, however, enough lumber and water power to justify the establishment of more wood-using industries than are now in the area.

Recreation Hunters, fishermen, tourists and summer residents flock to all parts of the Kennebec watershed. Fishing and hunting are lode-stones for many, while others are attracted by varied scenery, clean bathing beaches and good boating.

Transportation The Kennebec River is navigable to Augusta, 44 miles from the mouth. The controlling depth is 11 ft. at low water. On the main river above Augusta and on the tributaries water transportation is confined to log driving, an indispensable phase of the lumber industry.

The lower two-thirds of the basin is covered with a network of primary and secondary highways sufficient in number to meet local needs, but recommendations have been made for improvement of certain major routes to facilitate the growth of the recreation industry. Chief among these are a transverse route from Lewiston to Bangor and a river valley route from Augusta to Jackman and the Quebec border. In the wilderness section roads are few, but thus far have been sufficient to meet the requirements of the area. An additional recreational asset to the Kennebec basin would be realized by the construction of a parkway already recommended by the Maine Planning Board and the New England Regional Planning Commission. This parkway would enter Maine in the Rangeley Lakes section, follow the Dead River branch of the Kennebec, pass south of Moosehead Lake and continue into the Katahdin section of the Penobscot basin.

South of the wilderness section ample railway transportation is provided by the Maine Central Railroad. The extreme northern part of the basin is crossed by the main line of the Canadian Pacific from Quebec and Montreal to the Maritime Provinces.

The lower end of the basin is traversed by the Boston-Bangor airway. Regular transport service over this route is provided by the Boston and Maine Airways with scheduled stops at Augusta and Waterville. The projected route of the Canadian airway from Montreal to the Maritime Provinces crosses the upper end of the basin. An airway from Waterville to Greenville has been suggested as desirable in the interests of the Moosehead Lake recreation area. Airports and landing fields are located at Augusta, Waterville, Farmington, Skowhegan, Pittsfield, Greenville and Jackman.

WATER USE AND CONTROL

Pollution Domestic wastes from ten communities that had a total population of over 64,000 people in 1930 are introduced into the main stream or into the tributaries near their outlets. The largest communities are Waterville and Augusta, with populations of 15,454 and 17,198 respectively. Trade wastes from approximately 54 plants enter streams of the Kennebec basin. Of these plants, twenty-three textile mills, with 6,000 employees, and seven pulp and paper mills, with 2100 employees, are the principal sources of trade wastes.

In 1930 the Maine pulp and paper companies financed a survey of pollution conditions in the Kennebec from Madison to South Gardiner. Distinct sewage pollution was shown by the bacterial count of the river, and by the fact that dissolved oxygen content was less than 5 parts per million at all points in the upper river. In the tidal waters, at South Gardiner, the dissolved oxygen content of the water was about 3 parts per million, the minimum desirable for fish life. In general, the results of the investigation showed a rise and fall in the number of bacteria due to the alternate discharge of raw sewage and destruction of bacteria along the course of the river.

One of the worst sources of pollution in the main river would be eliminated by the establishment of sewage treatment works at Waterville. Purification of domestic sewage, together with partial treatment of industrial wastes, would relieve the load on the water purification plant at Richmond, which draws its water supply from the river.

Commercial and sport fishing in the tidal portion of the Kennebec are now impossible. Although almost no desirable species of fish now occupy the river, it is uncertain whether the economic loss incident to the lack of commercial and sport fish is as great as the expense of devices and procedures required to make possible their return.

Local sanitary experts state that (1) the dilution capacity of this stream is probably not at present strained to a point seriously threatening the public health; (2) the ocular nuisance is restricted to a few feet around each outfall; (3) when the ocular nuisance is so restricted, local citizens do not recognize any threat to the public health; (4) the debt structure of nearly all Kennebec basin municipalities renders impractical the assumption of community liability for the installation of treatment plants, although there is little doubt that future citizens will insist upon stream purification.

Commendable progress would be gained by an impartial, technical survey to determine: the degree and distribution of pollution; the relative significance of the various outfalls of domestic and trade wastes; the maximum permissible pollution; the identity of those communities and industries which can, individually or together, most economically install treatment plants; the feasibility of methods of refining trade waste; the practicability of deriving by-products from industrial waste; and the social or economic benefits which may reasonably be anticipated from stream purification. The survey should give special attention to the recreation interests and their future expansion, which means that particular study should be made of the pertinent summer conditions in lakes, ponds, and adjoining coastal sections in addition to the conditions in effect throughout the year along the streams in the basin.

Water Supply There is an abundant supply of surface and ground water in this basin. No communities of over 500 population are without public water supplies. Of the thirty-four water supply systems in the basin, nearly two-thirds rely upon lake or pond sources, and about half have chlorination plants.

The largest supply is that of the Kennebec Water District, which supplies chlorinated water from China Lake to Waterville, Fairfield and Winslow. Augusta uses water from Carleton and Winthrop Ponds after subjecting it to chlorine and corrective lime treatment. The Richmond supply, taken from the lower reaches of the main river, is filtered and chlorinated.

Control of pollution in the Kennebec River is desirable, not only from the standpoint of public health, but also because paper mills and other industries require quantities of pure water for manufacturing processes. The sanitary survey previously recommended could readily and properly include the collection of data necessary in selecting sources of supply for public water systems and for the industries which demand large volumes of clean water. The possible expansion of communities and the resultant increase in their water supply needs should also be considered in this survey.

Flood Control The large amount of natural storage at the headwaters, the numerous flat areas along the river, the absence of steep river slopes, and the heavy timber growth in the upper portion of the basin--all combine to protect the Kennebec River from extreme floods.

Moosehead Lake, with its high degree of storage regulation, is the principal flood-reducing factor. The highest runoff in the basin occurs between Moosehead Lake and the Forks, where the steep slope of the river and of the country drained by the river aggravates flood conditions. Moxie Lake effectively controls the 89 square miles above its outlet. Below Bingham the river has low flood characteristics due to the numerous lakes and ponds in this section and to its moderately sloping topography.

Although by far the most serious flood to date from the standpoint of monetary losses, the 1936 flood was not the highest on record, for the peak flow of December, 1901 was 156,800 cubic feet per second as against 154,000 cubic feet per second for the peak flow in March, 1936. The highest floods recorded at the Waterville gaging station are as follows:

Date	Maximum Discharge C.F.S.	Runoff C.F.S. per Sq.Mi.
May 1832	140,000**	32.8
March 1896	113,000*	26.0
December 1901	156,800*	36.6
May 1923	135,000*	31.4
March 1936	154,000*	31.6

*Peak discharge.
**Unofficial

The estimated damages in 1936 amounted to $1,631,000. divided between direct damages of $1,356,000 and indirect damages of $275,000.

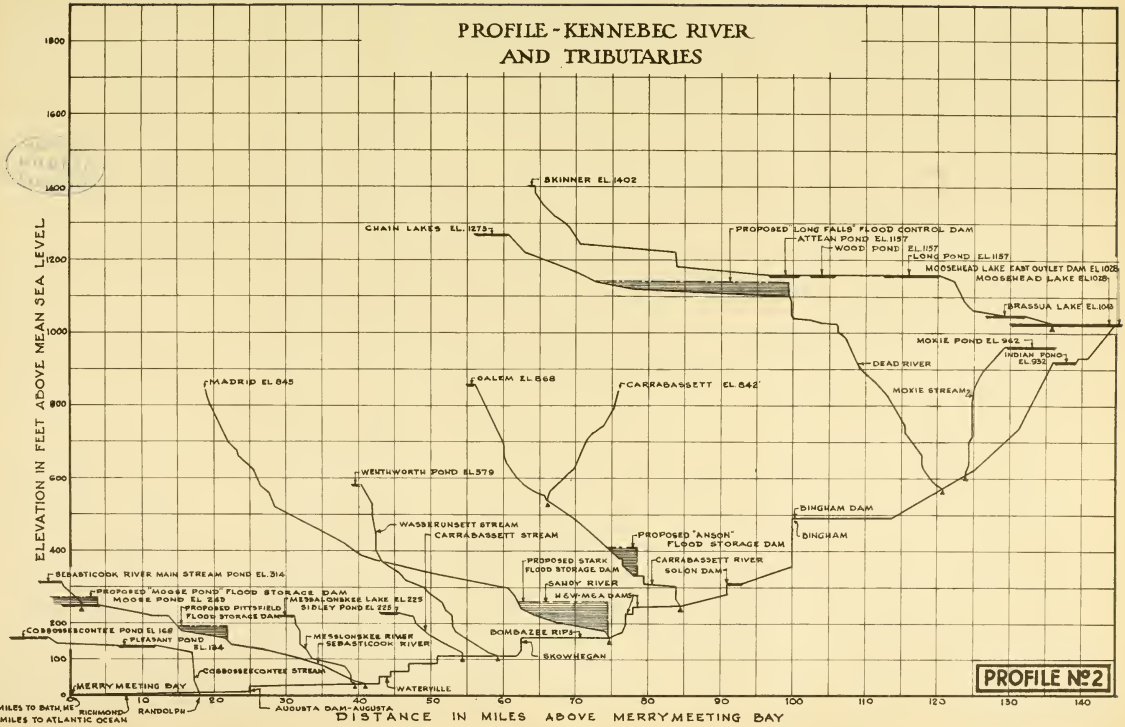
The Army Engineers have recently made a survey of the Kennebec River under authority of the Committee on Commerce of the United States Senate and have investigated 27 sites, of which the five where development for flood control could be accomplished with the greatest economy are:

Site	River	Drainage Area (Sq.Mi.)	Elevation Spillway Crest (Ft.)	Capacity (Acre-Feet)	Runoff Equivalent (Inches)
Long Falls	Dead River	521	1140.0*	223,000	8
Anson	Carrabassett	341	405.0	130,000	7.15
Stark	Sandy River	625	255.0	170,000	5.1
Moose Pond	Sebasticook	212	265.0	105,000	9.3
Pittsfield	Sebasticook	383	185.0	113,000	5.5

*Flood control only: for alternative combined power and flood control project, spillway elevation would be 1154; power storage elevation limit, 1145.

All five sites were studied by the Army Engineers to determine possibilities for combined storage for power and flood control purposes, the power storage to be provided by reservoir capacities from the bottom of the dam to a satisfactory elevation, and the flood control storage to be provided in a definitely reserved portion of the reservoir.

Only one of the 5 reservoirs considered, that at Long Falls on the Dead River, showed attractive possibilities for combined flood and power storage. Operation of storage for best prime flow at the dam site, as well as downstream from the site, came under consideration. The secondary power was


PROFILE - KENNEBEC RIVER
AND TRIBUTARIES
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
1800
1600
1400
1200
1000
800
600
400
200
100
0
SKINNER EL. 1402
CHAIN LAKES EL. 1273
PROPOSED LONG FALLS FLOOD CONTROL DAM
ATTEAN POND EL. 1157
WOOD POND EL. 1157
LONG POND EL. 1157
MOOSEHEAD LAKE EAST OUTLET DAM EL. 1025
MOOSEHEAD LAKE EL. 1025
BRASSUA LAKE EL. 1043
MOXIE POND EL. 962
INDIAN POND EL. 930
DEAD RIVER
MOXIE STREAM
MADRID EL. 845
SALEM EL. 868
CARRABASSETT EL. 842
WENTWORTH POND EL. 379
WASSERUNSETT STREAM
CARRABASSETT STREAM
PROPOSED "ANSON" FLOOD STORAGE DAM
BINGHAM DAM
BINGHAM
SEBASTICOOK RIVER MAIN STREAM POND EL. 314
PROPOSED "MOOSE POND" FLOOD STORAGE DAM
MOOSE POND EL. 283
PROPOSED PITTSFIELD FLOOD STORAGE DAM
MESSALONSKEE LAKE EL. 225
SIDLEY POND EL. 228
PROPOSED STARK FLOOD STORAGE DAM
CARRABASSETT RIVER
SOLON DAM
SANDY RIVER
HEWES DAMS
COBBOSSEECONTEE POND EL. 168
PLEASANT POND EL. 134
MESSALONSKEE RIVER
SEBASTICOOK RIVER
BOMBAZEE RIPS
SKOWHEGAN
COBBOSSEECONTEE STREAM
MERRYMEETING BAY
WATERVILLE
RICHMOND
RANDOLPH
AUGUSTA DAM-AUGUSTA
12¼ MILES TO BATH, ME.
26¼ MILES TO ATLANTIC OCEAN
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
DISTANCE IN MILES ABOVE MERRYMEETING BAY
PROFILE №2

not investigated, as it has no value in Maine. There are 325 feet of developed head below the site, of which 312 feet are utilized by installations of sufficient capacity to benefit from increased low flow.

The development of the other four reservoirs for combined power and flood control would not be so desirable as their development for flood control alone, according to the findings of the Army Engineers. Nevertheless, these reservoirs, if developed primarily for flood control, could be so operated as to afford incidental benefits to power developments downstream. The approximate amount of the increased primary power output which would result from the operation of the four reservoirs would be 14,800,000 kw.-hrs. If only the Anson and Stark Reservoirs were developed the increased annual primary output would be 10 million kw.-hrs.

Power The Kennebec River is one of the great potential sources of power in New England. Of the estimated available capacity of 376,567 horsepower on the main river and tributaries, 160,800 horsepower are at present developed. Between the outlet of Moosehead Lake and the head of tidewater, at Augusta, the river falls 1026 feet. The uppermost development on the main river is the Wyman plant of the Central Maine Power Company, at Bingham, about 76 miles above Augusta. Along this 76-mile stretch there are 13 installations which utilize a total fall of 325 feet obtained at 9 dams. The total power developed amounts to 139,746 horsepower. The Wyman plant, the largest in Maine, has a present installed capacity of 68,000 horsepower, (ultimately 102,000 h.p.) under a head of 135 feet. In March, 1936 the dam at Fairfield was partially destroyed by flood, so that the two plants utilizing the 12-foot head at this point and developing 364 horsepower are at present not in use. The 1650 horsepower plant at Benton Falls on the Sebasticook was destroyed in March, 1936. A 28-foot dam at Solon was formerly used to develop 4000 horsepower, but at present the site is unused. This 28-foot head is not included in the total of 325 feet mentioned above.

Numerous small plants located on the tributaries have a total installed capacity of 21,054 horsepower, under heads ranging from 8 feet to 215 feet. On Messalonskee Stream 4 plants of the Central Maine Power Company develop 10,150 horsepower, half of the total power on the tributaries.

Public utilities develop about two-thirds of the total power of the basin; textile, pulp and paper, and lumber mills account for the other third. The division between these two classes of use is shown in Table VI-A.

The present developments of 1000 horsepower or over on the main river and the tributaries, as listed by the Augusta Office of the U. S. Geological Survey, January 1, 1937, are as follows:

River	Location or Plant	Wheel Capacity H. P.
Kennebec River	Augusta	3,032
Kennebec River	Augusta	4,307
Kennebec River	Waterville	10,560
Kennebec River	Winslow	5,916
Kennebec River	Shawmut	7,200
Kennebec River	Weston	17,350
Kennebec River	Madison	14,030
Kennebec River	Madison	8,170
Kennebec River	Wyman	68,000
Messalonskee Stream	Waterville	2,100
Messalonskee Stream	Waterville	1,250
Messalonskee Stream	Rice Rips	2,800
Messalonskee Stream	Oakland	4,000
Sebasticook River	Fort Halifax	1,700
Sebasticook River	Burnham	1,735
Cobbosseecontee Stream	Copsecook Mill	1,000
Cobbosseecontee Stream	Gardiner	1,300
		154,450

These plants account for 154,450 horsepower; the remaining 6350 horsepower is developed at 32 plants having installations ranging from 100 to 500 horsepower.

The majority of the undeveloped power available on the main river is in that portion of the river between Bingham and the outlet of Moosehead Lake; it amounts to about 110,440 horsepower, on a 60% of the time basis. Below Bingham, the 60% power amounts to about 39,000 horsepower. Table VII-A gives the estimated installed capacities at several of the undeveloped sites on the main river, using an assumed turbine efficiency of 80 per cent. There is an additional 51,640 horsepower available on the tributaries, but it is unlikely that much of this will be developed in the near future because of the distance to a suitable market. The potential power sites on Dead River give greatest promise of development, because if a storage reservoir were built at Long Falls on that river it could be used to regulate stream flow over 413 feet of undeveloped head.

The U. S. Army Engineers have considered the power possibilities on this river in connection with their flood control investigations. An installation at the Long Falls site has been studied in conjunction with the reservoir. The head which could be utilized here would be 81 feet; the installed capacity, about 11,000 horsepower.

The present natural storage amounts to 932,000 acre-feet; the water area, about 300 square miles, or 5% of the watershed. Moosehead Lake, with a capacity of 542,000 acre-feet and a water surface area of 117 square miles, controls the runoff from an area of 1240 square miles, or 22% of the total basin. One inch of runoff from this entire area raises the water level of Moosehead less than one foot.

The drainage areas, water areas and capacities of the principal existing storage reservoirs are as follows:

Lake or Pond	Drainage Area-Sq.Mi.	Water Surface - Sq. Mi.	Capacity Acre-Feet
Moosehead Lake	1240	117.0	542,000
Brassua Lake	708	15.1	206,000
Wood and Attean Ponds	320	7.8	8,000
Long Pond	520	5.0	14,400
Roach Ponds	117	8.0	29,000
Moxie Ponds	80	3.0	16,100
Pierce Pond	18	2.3	14,300

Additional available storage in the basin, as reported in the 1st Annual Report (1920) of the Maine Water Power Commission, amounted to 508,700 acre-feet. (Of that amount 206,000 acre-feet have since been developed in Brassua Lake.) It was estimated that this additional storage would increase the power available 50% of the time at existing plants by more than 60,000,000 kilowatt-hours a year. Tables VIII-A and IX-A summarize information on existing storage and potential storage, respectively.

Navigation The total navigable distance on the Kennebec through Merrymeeting Bay to Augusta is 44 miles. The project depth at mean low water is 16 feet to Gardiner and 11 feet from there to Augusta. The traffic in 1935, most of which was in coal, totalled 166,976 tons. Considerable shoaling has occurred and the desirability and extent of work required to restore project depths is being investigated.

Erosion Effects of sheet erosion are in evidence throughout the inhabited portions of the main river valley. As yet these effects are, with minor exceptions, slight; nevertheless, erosive action is steadily destroying fertile river valley soils.

Drainage An extensive tidal estuary receiving the flow of the Kennebec and Androscoggin Rivers bears two names locally--Merrymeeting Bay and Kennebec River-- the applications of which are vague and tend to be interchangeable. The shores of this estuary are largely salt-marsh and flats which afford food and shelter for migratory birds as well as for native wildlife. In the vicinity of settlements the marsh land, a prolific breeding place of mosquitoes, constitutes a public nuisance. Drainage will abate the nuisance, but if too extensively applied will obliterate the very characteristics that now make the marsh a natural stopping place of migratory birds. Therefore, a balance of benefits must be secured wherein small swamp areas adjoining settlements may be drained to reduce the local mosquito nuisance but the larger part of the marshland left in a condition favorable to wildlife.

The Maine State Entomologist has suggested that approximately 2000 acres of marsh lying in three coastal towns near the outlet of the estuary be drained for the benefit of permanent and summer residents. Since the area under consideration represents less than one-tenth of the marsh land in the vicinity, and since its proximity to communities reduces its attractiveness to wildlife, it is probable that drainage of these 2000 acres will not appreciably reduce the wildlife benefits now enjoyed.

The characteristically sharp slope of the basin above the estuary reduces swamp areas to land pockets or lake, pond and stream shores. All swamps and marshes shelter wildlife, and only in small, scattered localities does the mosquito nuisance justify artificial drainage.

Recreation Depreciation of recreational attractions in the Kennebec basin will cause depletion of the summer settlements; by the same token, preservation of water resources will tend to increase the number of hunters, fishermen, and vacationists who come to this region where water is the chief recreational asset. The water assets are so varied that it is easy to affect one adversely when striving to correct another. Specifically, development to effect complete mosquito control in the Merrymeeting Bay district would destroy one of the largest gathering places for migratory birds in New England. The Merrymeeting Bay bird problem has been reviewed by the National Biological Survey, particularly in reference to the damage done to feed grounds by silt deposited during the March, 1936 flood.

The absence of desirable fish species in the lower Kennebec could be corrected, but the procedure would probably cost more than it is worth. Reconstruction of fishways and stream purification may prove practical at a future date. Abundant fish life still exists in the tributary streams and water bodies; hence, water control developments should avoid any fluctuations in water level which are detrimental to fish. It is known that on reservoirs which are drawn down during the bird-nesting season, waterfowl nests are stranded and the eggs or chicks abandoned. Also it is believed that deer have migrated when the reservoirs upon which they relied were drained until boggy shores were exposed, or until the water became stagnant.

The absence of intensive recreational development along the attractive shores of the Kennebec above the mouth of the Androscoggin is not easily explained, but the situation is probably not due to stream pollution.

It seems unwise to indicate recreation and wildlife problems beyond recommending restricted drainage in Merrymeeting Bay. For other parts of the Kennebec basin all proposals should be thoroughly reviewed by recreation and wildlife authorities prior to final approval.

ANDROSCOGGIN BASIN

GENERAL DESCRIPTION

The Androscoggin River basin is the third largest interstate drainage basin in New England, being exceeded in area by the Connecticut and Merrimack basins only. Its total area is 3470 square miles; of this total, New Hampshire contains 695 square miles and Maine 2775 square miles. The long axis of the basin is about 110 miles, while the short is about 55 miles. The headwaters of the Androscoggin lie near the intersection of the Canadian, New Hampshire and Maine boundaries and drain into Umbagog Lake on the boundary between New Hampshire and Maine. The Androscoggin flows out of the New Hampshire side of Umbagog Lake; follows a southerly course for about 35 miles to Gorham; turns abruptly east and, after flowing in this direction about 20 miles, crosses the state line; continues easterly to Bethel and then southeasterly to Brunswick, at the head of tidewater; and finally enters Merrymeeting Bay, where it joins the Kennebec. The length of the river from Umbagog Lake to Merrymeeting Bay is about 170 miles, of which nearly 120 miles are in Maine. If the tributaries above Umbagog Lake are counted, the total length of the main river and its principal headwater feeder is 200 miles.

The general level of the basin is the highest of any on the Atlantic seaboard. The headwaters rise in rough, mountainous country with land elevations averaging about 3000 feet above sea level. From the rugged upper area the topography graduates into a somewhat irregular and, near the mouth, comparatively low and rolling terrain. Of the 1243 feet offall in the river between Umbagog Lake and tidewater, 800 feet occur between the Lake and the foot of Rumford Falls in a little over half the length of the river. The 1913 report of the State Water Commission listed 195 bodies of water as tributary to the Androscoggin. The total water area is 143 square miles, or 4.1% of the drainage area. Mooselookmeguntic Lake, with 26.0 square miles of water surface, is the largest body of water in the basin.

The principal rock formation is granite, with an overburden of glacial sand and gravel. Nearly 85% of the basin area is woodland, of which a large percentage has been cut over. The crop land, found mostly along the lower half of the river valley, accounts for about 7% of the watershed area.

The average annual precipitation varies from 33 inches, near the source, to 40 inches in the lower sections. In the northern part of the basin, summer and fall have slightly higher rainfall than the other seasons, but near the mouth the monthly distribution is uniform. The summer temperature averages from 63° to 66° and the winter from 24° to 31°, both averages varying with the altitudes.

The most important tributaries of the Androscoggin are the Magalloway River and the Rangeley Lakes system, the two headwater systems which unite to form the main river.

The Magalloway drains the Parmachenee Lake system in the uppermost part of the basin. It has a length of about 30 miles and drains about 450 square miles before joining the Androscoggin at the outlet of Umbagog Lake. Sawyer, or Aziscohos Lake, an artificial reservoir, is the largest water body in the Magalloway river system. It is about 14 miles long, has a water area of 10.5 square miles, and controls about 233 square miles of drainage.

The Rangeley Lakes system, which includes Kennebago, Rangeley, Mooselookmeguntic, Richardson and Umbagog Lakes and their tributary streams, drains the rugged and largely undeveloped country of northwestern Maine. The drainage area of the lake system is about 635 square miles, of which 70 square miles, or 11%, is water area.

Discharge records at gaging stations on the main river and some tributaries are kept by the U. S. Geological Survey with the cooperation of the state of Maine. Detailed data for these stations can be found in the U. S. Geological Survey's Water Supply Papers, Part I - North Atlantic Slope Basins. In Table III-A are given summarized data for these stations, obtained from unpublished records of the District Engineer at Augusta and from the published papers of the survey.

The hydrograph on Chart 3 shows the average monthly runoff at Rumford during the past 15 years. The average runoff from the drainage area of 2090 square miles above Rumford is 1.66 cubic feet per second per square mile.

HUMAN OCCUPANCY

Population The Androscoggin basin had a population in 1930 of 145,000--nearly 10% more than in 1920. There is a considerable variation in the distribution of the population: the average density for Oxford county, in the north, is 21 per square mile, while that for Androscoggin county, in the southern industrialized section, is 155 per square mile. The basin population, including 22,000 people in New Hampshire, is equal to 18% of the population of the State of Maine.

The twelve cities and towns of more than 2500 population have three-fourths of the inhabitants of the watershed. The 1930 population of these communities was:

Lewiston, Me.	34,948
Auburn, Me.	18,571
Berlin, N. H.	20,018
Rumford, Me.	10,340
Brunswick, Me.	7,604
Mexico, Me.	4,767
Lisbon, Me.	4,002
Paris, Me.	3,761
Livermore Falls, Me.	3,148
Norway, Me.	3,145
Jay, Me.	3,106
Gorham, N. H.	2,763

Nearly two-thirds of the population of the basin is classed as urban.

The industrialized character of this region accounted for the 10% increase in population between 1920 and 1930 in contrast to that of less than 4% in the entire state of Maine. Practically the entire gain occurred in towns having over 2500 population, of which only two, Lisbon and Jay, lost in this period. The communities which gained are located for the most part along the main river, as shown in Map 7. Communities that lost population lie along the edges of the forest areas and near the borders of the basin. On account of its manufacturing activities this section of the state will probably continue to grow more rapidly than will Maine as a whole.

Agriculture Most of the farm land in the basin lies along the main streams in the southern part of the watershed. Parts of it are above the state average in fertility, as indicated by the value per acre. Other portions, especially in Oxford county, are rocky and unsuitable for tillage. The total value of agricultural products was, in 1930, approximately $9,000,000. The principal sources of farm income are poultry and dairy products, field and orchard crops. This region has the advantages of large local markets and excellent transportation facilities to outside points.

It is likely that the local market factor will enable farming activities to keep pace with industrial growth in the basin. Access to outside markets such as Portland and Boston will probably encourage a continuance of specialized farming, particularly in the dairy and poultry lines. This watershed, in common with others in Maine, has certain rural problem areas along the wilderness borders.

Industry The value of products manufactured in the Androscoggin valley in 1933 amounted to about 40% of the Maine total. Textiles, centered in Lewiston, boots and shoes in Auburn, and pulp and paper in Berlin and Rumford constitute the principal manufactures in the basin.

Industrial growth will be governed largely by the general conditions in the shoe, textile and paper industries, and by labor conditions. The water resources for power and manufacturing purposes, the timber supply, and transportation facilities offer advantages that should attract new industries in the future.

Mining Granite quarries, at one time quite active, are still operated, but with limited output. There are also mica and lime deposits but production in recent years has been of small volume.

Lumbering Lumbering has been a very active industry, due to the vast supply of timber and pulp-wood, mainly spruce and fir, in the northern part of the basin. There are also large quantities of hardwood in the central part of the watershed and white pine in the southern section. The timber cut in the Maine portion of the basin for 1933-1934 averaged about 100,000,000 board feet per year, of which about 80% was pulpwood. This cut was heavier than that of either the Penobscot or the Kennebec watersheds. In addition, there was substantial production in Coos county, in New Hampshire. Although there is a moderate amount of manufacturing in wood-using industries, the bulk of the timber is used for pulpwood, and the degree of future development in the lumbering industry will depend to a great extent upon the condition of the pulp and paper industry.

Recreation Summer homes and hotels are scattered throughout the entire basin. Of the many sporting and recreation centers in this basin Rangeley Lakes and Poland Spring are probably the best known. Boating and bathing in the main streams are handicapped by pollution and by the continuous fluctuation of water levels incident to water power production. The tributary streams and lakes shelter many species of fish and attract many vacationists.

Transportation In common with other rivers of Maine, transportation on the Androscoggin River is confined to log driving. Brunswick, only 5 miles above the Kennebec River channel, is at the head of tidewater. In 1831 and 1916 the Army Engineers investigated the possibility of extending navigation from Merrymeeting Bay to Brunswick, and reported that the cost of such a project would greatly exceed the benefits.

The southern half of the basin has a highway system adequate to meet present needs. The northern half, largely wilderness, has sufficient roads to provide access to lake properties and settlements. A trunk highway extends along the Androscoggin River from the lower valley through Rumford and west into New Hampshire. Traffic into and across the lower part of the basin is so great as to demand construction of an improved trunk highway in this section, and such a highway has been recommended by the Maine State Planning Board and the New England Regional Planning Commission.

The southern part of the basin is served by the main line and branches of the Maine Central Railroad and by the line of the Grand Trunk Railroad from Portland to Montreal. A branch of the Boston and Maine Railroad runs from Berlin, N. H. to Whitefield in the Connecticut Valley. The railroads formerly penetrating the Rangeley Lakes region have been abandoned and replaced by bus lines.

No regularly scheduled air transport service is provided at any point in this basin. Airways from Portland to Rangeley and from Waterville along the Androscoggin valley to Whitefield, N. H., Montpelier and Barre, Vermont, have been suggested. There are landing fields at Auburn, Bethel and Berlin.

WATER USE AND CONTROL

Pollution Of the major Maine rivers, the Androscoggin needs first consideration in a program for pollution abatement. There are 130,000 persons living in the Androscoggin valley, concentrated in the several cities and towns along the river. These points of concentrated population are also industrial centers, and neither the domestic sewage nor the industrial wastes receive treatment before being discharged into the river. Elsewhere in Maine higher concentrations of population may exist but in no one place is the total number of persons affected so great as on the Androscoggin. The principal sources of domestic pollution are Berlin and Gorham, New Hampshire; Rumford and Mexico, Maine; Livermore Falls and Jay, Maine. Paper mills are located at each of these points, except Lewiston-Auburn, where there are several textile and shoe plants. The Maine section of the basin contains thirty-four boot and shoe plants, twelve pulp and paper mills, and fourteen textile factories, employing altogether nearly 19,000 workers.

In 1930 a river survey, financed by the Maine pulp and paper companies, covered the stream to the New Hampshire line. The samples taken near the state line contained four parts per million of dissolved oxygen, the bare minimum necessary to support fish life; it was found that even heavier pollution existed at

Auburn and Lewiston. Between Lewiston and Brunswick the river falls approximately 100 feet, and the attendant aeration of the water offsets the effect of wastes entering the river between these points. The Androscoggin basin as a whole carries a greater pollution load per square mile of drainage area than any other Maine stream, with the possible exception of the Presumpscot.

Because of the low oxygen content and the lack of adequate fishways, the main stream of the Androscoggin system is practically devoid of desirable fish species. This situation does not present so important a problem, in the minds of public health officials, as the insanitary condition of the river at Lewiston--Auburn. However, the financial conditions of these two cities prevent immediate assumption of responsibility for providing proper treatment of their domestic wastes which, introduced directly into the river, materially accentuate the local sanitary hazard. Nor are the industrial concerns of the valley able to undertake proper refinement of their trade wastes.

Since New Hampshire contains 20% of the drainage basin and introduces wastes into the river, the pollution problem requires interstate cooperative action. The 1930 survey points out the necessity for more detailed information on sanitary conditions, so that reduction of pollution to the practical minimum can be achieved intelligently and economically. The amounts chargeable to pollution for destruction of residential, industrial and recreational assets, the proper means of financing and operating sanitary control, as well as the legislation necessary to facilitate interstate cooperation on pollution problems --all require thorough investigation. Special attention should be given to recreation and wildlife because these assets, potentially great, have thus far suffered the most from pollution.

Water Supply Abundant surface and ground water is available in the Androscoggin basin, and all concentrated communities are served by adequate public water supplies. Although the basin has a fairly high population density, so that water supply developments are numerous, nevertheless, ample opportunities for new surface and ground water supply development exist. In New Hampshire, Berlin (pop.20,018) is served by a public surface supply which receives chlorination. Gorham, Errol and Randolph also have organized water supply systems. Milan is the only town of any size in the New Hampshire portion of the Androscoggin basin without a water supply system.

Twenty-four communities in the Androscoggin valley in Maine have water supply systems, the sources of which are divided about equally among lakes and ponds, wells and springs, and small tributary streams. No municipalities take water directly from the main river. The largest cities, Lewiston and Auburn, use chlorinated water, taken from Auburn Lake. The one filtration plant in the basin is located at Mechanic Falls.

The paper mills scattered along the Androscoggin in New Hampshire and Maine vitally affect the social and industrial well-being of the valley. These mills require large quantities of clean water for their manufacturing processes. Thus any survey of water supply needs should give careful consideration not only to present and future public water uses, but also to industrial uses of large volumes of pure water.

Flood Control The flood hazard in the Androscoggin valley occurs between Errol, New Hampshire and Brunswick, Maine, in which stretch of river the drainage area is controlled to only a small degree. Above Errol there is excellent control which is effective for points downstream. The effectiveness of this control diminishes directly as the tributary drainage area increases.

Between Errol and Rumford the tributaries have a quick runoff which causes peaking of the flow and results in the overflowing of the intervale land. Like conditions prevail between Rumford and Livermore Falls.

Floods are usually caused by heavy rain and the quick melting of snow. In March 1936 the peak flow at Auburn reached 135,000 cubic feet per second, and the damages suffered from this flood amounted to $4,392,000 divided between direct losses of $2,756,000 and indirect losses of $1,636,000. Most of the loss was incurred in Maine, that in New Hampshire being only $160,000.

Previous high floods have been recorded in 1896, 1923 and 1927. The floods of 1896 and 1923, both spring floods, caused comparatively little damage; that of 1927, a November flood, resulted in losses at Berlin and Gorham, New Hampshire of $350,000 to $400,000, exclusive of damages to railways. The peak at Auburn was, however, 60,000 cubic feet per second, less than in 1896 or 1923.

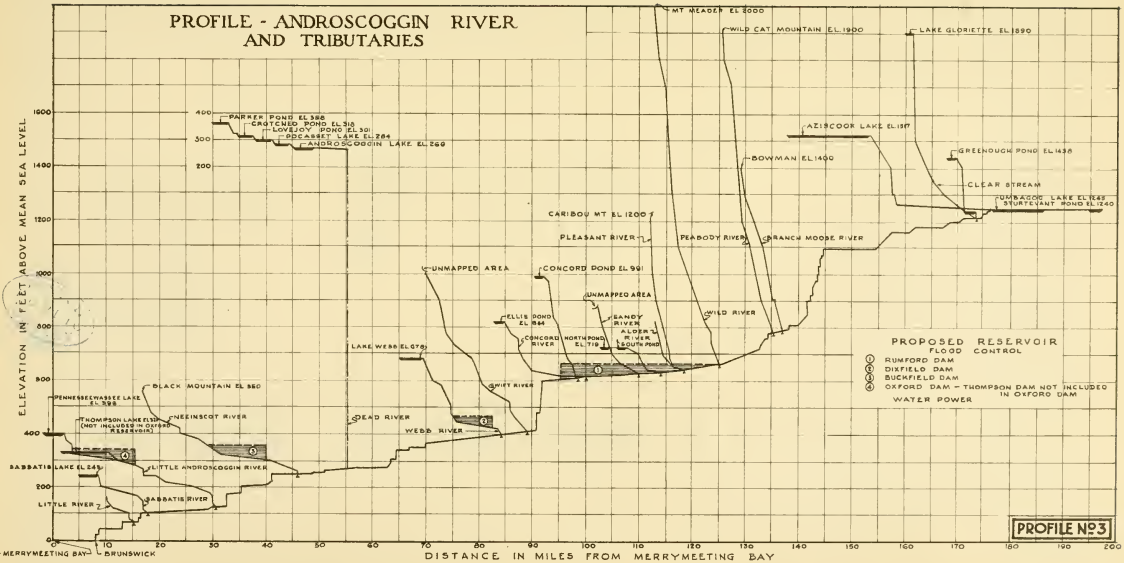
Much of the flooding and resultant damage in heavy spring freshets is due to ice-jams. This jamming is aggravated by bridge abutments and piers and other obstructions in the river, which are thus often responsible for excessive damage. If flood losses are to be reduced, it is highly desirable that in the future bridges be built with ample water ways and that highways be located above flood levels.

In the investigations made by the U. S. Army Engineers in 1936 of flood control sites on the Androscoggin River, the four most favorable sites having possible value for flood control were:

Reservoir Site	Drainage Area (Sq.Mi.)	Reservoir Capacity (Acre-feet)	Runoff Inches
Oxford	231	92,000	7.5
Buckfield	156	61,000	7.3
Dixfield	125	40,300	6.0
Rumford	965	295,000	5.7
TOTAL	14,077	508,300	

The Army Engineers' preliminary analysis of the annual charges of these reservoirs and the annual flood benefits shows that the flood benefits would be only half to two-thirds of the total annual costs.

Power The Androscoggin River has been developed more highly than any other river in Maine, largely because of the steepness of the river slope, the large amount of storage, and the demand for power created by the textile and pulp and paper plants along the river. Of the approximately 353,000 horsepower available on this river, 246,469 horsepower are at present developed. This is 45% as much as the total installed capacity in all Maine.


PROFILE - ANDROSCOGGIN RIVER AND TRIBUTARIES
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DISTANCE IN MILES FROM MERRYMEETING BAY
1- MERRYMEETING BAY
BRUNSWICK
PARKER POND EL 386
CROTCHED POND EL 310
LOVEJOY POND EL 301
POCASSET LAKE EL 284
ANDROSCOGGIN LAKE EL 269
MT MEAGER EL 2000
WILD CAT MOUNTAIN EL 1900
LAKE GLORIETTE EL 1890
AZISCOOS LAKE EL 1317
GREENOUGH POND EL 1438
BOWMAN EL 1400
CLEAR STREAM
UMBAGOG LAKE EL 1242
STURTEVANT POND EL 1240
CARIBOU MT EL 1200
PLEASANT RIVER
PEABODY RIVER
BRANCH MOOSE RIVER
UNMAPPED AREA
CONCORD POND EL 901
UNMAPPED AREA
SANDY RIVER
ALDER RIVER
SOUTH POND
ELLIS POND EL 864
CONCORD RIVER
NORTH POND EL 719
WILD RIVER
LAKE WEBB EL 678
SWIFT RIVER
BLACK MOUNTAIN EL 860
PENNESSEEWASSEE LAKE EL 598
THOMPSON LAKE EL 518 (NOT INCLUDED IN OXFORD RESERVOIR)
ANEEINSCOT RIVER
DEAD RIVER
WEBB RIVER
LITTLE ANDROSCOGGIN RIVER
SABBATIS LAKE EL 245
SABBATIS RIVER
LITTLE RIVER
PROPOSED RESERVOIR FLOOD CONTROL
1 RUMFORD DAM
2 DIXFIELD DAM
3 BUCKFIELD DAM
4 OXFORD DAM - THOMPSON DAM NOT INCLUDED IN OXFORD DAM
WATER POWER
PROFILE No 3

Of the total power developed in the Androscoggin basin, over three-quarters, or 185,619 horsepower, is in Maine, with 179,023 horsepower on the main river and 6596 horsepower on the tributaries. In the New Hampshire portion of the basin 60,850 horsepower is developed, all on the twelve-mile stretch of the main river between Berlin and Shelburne. The total heads utilized on the main river in the two states are: New Hampshire, 291 feet; Maine, 484 feet. Three hundred thirty-three feet of head are developed on the tributaries.

Between 1910 and 1928, the installed capacity was increased from 123,455 to 242,831 horsepower, an average annual increase of 6632 horsepower; since 1928 net increase has amounted to only 3638 horsepower. This reduced rate of growth has been due in general to the economic depression, and in particular to the withdrawal of the textile industry from this area. The installation, in 1932, of a 68,000 horsepower plant on the Kennebec River at Bingham has undoubtedly contributed to the falling-off of power development on the Androscoggin.

According to unpublished data in the Augusta office of the U.S.G.S. the existing plants with wheel capacities of over 1000 horsepower are as follows:

River	Location or Plant	Wheel Capacity - H.P.
In Maine		
Androscoggin River	Brunswick	1932
Androscoggin River	Brunswick	4200
Androscoggin River	Brunswick	6000
Androscoggin River	above Brunswick	8084
Androscoggin River	Lisbon Falls	1489
Androscoggin River	Lewiston	23,666
Androscoggin River	Deer Rips	16,150
Androscoggin River	Gulf Island	27,000
Androscoggin River	Livermore Falls	10,800
Androscoggin River	Chisholm	9426
Androscoggin River	Jay	3500
Androscoggin River	Riley	6963
Androscoggin River	Rumford	4669
Androscoggin River	Rumford	14,744
Androscoggin River	Rumford Falls	39,000
Little Androscoggin River	Mechanic Falls	1907
In New Hampshire		
Androscoggin River	Shelburne	3000
Androscoggin River	Shelburne	4900
Androscoggin River	Gorham	2700
Androscoggin River	Gorham	6000
Androscoggin River	Cascade Mill(Berlin)	10,800
Androscoggin River	Cross Plant (Berlin)	4750
Androscoggin River	Glen Mill No.5(Berlin)	4000
Androscoggin River	Glen Mill B (Berlin)	4600
Androscoggin River	Glen Mill C (Berlin)	5100
Androscoggin River	Riverside (Berlin)	15,000

These 26 installations have a total of 240,380 horsepower, of which 179,530 is in Maine and 60,850 in New Hampshire. The remaining 6089 horsepower is developed at plants with installed capacities ranging from 120 to 900 horsepower.

The largest development on the Androscoggin is that of the Oxford Paper Company at Rumford Falls, where 39,000 horsepower is developed under a head of 98 feet; the second largest is the Central Maine Power Company's Gulf Island plant, above Lewiston, which has a wheel installation of 27,000 horsepower utilizing a head of 50 feet.

The best power sites on the main stream have already been developed, but investigations have revealed possibilities for developing 104,577 additional horsepower on the main river and its tributaries. Of this amount 94,760 would be on the main river, with 62,870 in Maine and 31,890 in New Hampshire. The sixteen undeveloped sites on the main river which are most promising are listed below:

Location	Drainage Area Sq. Mi.	Head Feet	Undeveloped horsepower for flow 60% of time
Donovan Rips	3290	14	4970
Ram Island Rips	2640	20	5920
East Peru	2350	20	5320
Dixfield	2210	17	4280
Rumford to Bear River	1840	16	3470
Bethel Rips	1700	20	4000
Pleasant River to Gilead	1670	25	4930
Gilead	1640	24	4660
(Maine--New Hampshire line)			
Shelburne	1550	15	2790
Peabody Rips	1510	20	3620
Pulsifer Rips	1400	35	5880
Below Pontoocook Dam	1250	55	8250
Above Pontoocook Dam	1240	15	2240
Mollidgewock Rips	1220	20	2920
Errol Dam and Rips	1100	25	3300
(New Hampshire--Maine line)			
Umbagog Lake to Pond-in-river	520	150	7800
Total			74,350

In view of the static market for power in this basin during the last few years it is doubtful if new privileges will be developed in the immediate future. A additional power is needed, there is greater likelihood of the redevelopment and improvement of existing plants.

The storage on the Androscoggin River is highly developed and is operated with little waste. The drainage area above the dam at Errol, amounting to 1095 square miles, is well controlled by storage reservoirs whose normal capacity i 678,500 acre-feet and which can be increased to 759,000 acre-feet. Additional storage of 103,500 acre-feet is obtainable in this area, and if added would raise the total of storage above Errol to 860,000 acre-feet.

Between Errol and Rumford very little storage is added, the total above Rumford being 688,000 acre-feet, only about 10,000 acre-feet more than that above Errol. Between Rumford and Brunswick, the increase in storage is 87,000 acre-feet, making the storage capacity above Brunswick 775,000 acre-feet.

The best site for new storage is below the confluence of the Swift Diamond and Dead Diamond Rivers. A reservoir here would impound about 90,000 acre-feet of water.

The U. S. Army Engineers, in connection with their flood control investigations on the Androscoggin River, carried out during 1936, found that a combined development for power and flood control at Rumford would be practicable. The flood control storage at this reservoir would be 295,000 acre-feet, and power storage would be 297,000 acre-feet; with a head of 33 feet, an installation of about 15,000 horsepower could be made. A reservoir at this site would furnish storage for installations below the site now developing a total head of 484 feet. An additional 71 feet of undeveloped head below the site would be benefitted by this storage.

The other sites investigated by the Army Engineers, in addition to that at Rumford, were at Dixfield, Buckfield and Oxford, where it was found that there could be developed reservoirs of 41,300 acre-feet, 61,000 acre-feet and 92,000 acre-feet capacity respectively.

Navigation There is no water-borne commerce on the river, not even to Brunswick, at the head of tidewater, about 3 miles upstream from Merrymeeting Bay. Thus far there has not been enough demand to justify the expense of providing navigation facilities.

Erosion Erosion occurs on many small areas throughout the basin, frequently on good farm lands. As in the Kennebec basin, the attendant problems are not serious, since only two areas exhibit moderate or severe conditions.

Drainage The characteristically sharp slope of the basin above the estuary reduces swamp areas to land pockets or lake, pond and stream shores. All the swamps and marshes shelter wildlife, but only in small, scattered localities does the local mosquito nuisance justify artificial drainage.

Recreation To preserve the social and economic values of recreation, particular care must be given to such natural factors and assets as fish and game population, attractive bathing and boating, and general scenic values. Pollution abatement along the main river would increase recreational use of the river banks and would make possible the return of desirable fish species. Nevertheless, the cost involved in such abatement might exceed the financial assets.

Too often recognition of the close relationship between all water resources and recreation is slight. Before being undertaken, all water resources improvement projects should be reviewed by authorities qualified to anticipate the reaction of each improvement upon recreation and wildlife assets.

PRESUMPSCOT BASIN

GENERAL DESCRIPTION

The Presumpscot River flows from Sebago Lake southeast a distance of 17 miles to Casco Bay, just north of Portland. The basin is about 55 miles long and has a maximum width of 20 miles. Its drainage area is 615 square miles, 436 square miles of which are above the outlet of Sebago Lake. Above Sebago Lake the main stream, called Crooked River, drains an area of somewhat less than 200 square miles in a distance of nearly 45 miles. The water area in the basin is 81 square miles or 13.1% of the total area, the largest percentage of water area in any Maine basin. Sebago Lake accounts for 45 square miles of this water surface.

The Presumpscot Basin is rolling except in the southern portion, which is comparatively level; the total fall below Sebago Lake is less than 270 feet. The rock formation is mostly granite having a soil cover of glacial sand and gravel. About 20% of the drainage area is cleared farm land, two-thirds of which was harvested in 1934. The remainder of the area, except for scattered settlements, is woodland, most of which has been cut over and is re-seeding to mixed hardwoods and conifers.

The average precipitation in the basin is about 42 inches annually, fairly evenly distributed throughout the year, and varying only slightly in the different parts of the basin. Average summer temperature is about 66° and average winter temperature varies from 20° to 24°, being milder near the ocean.

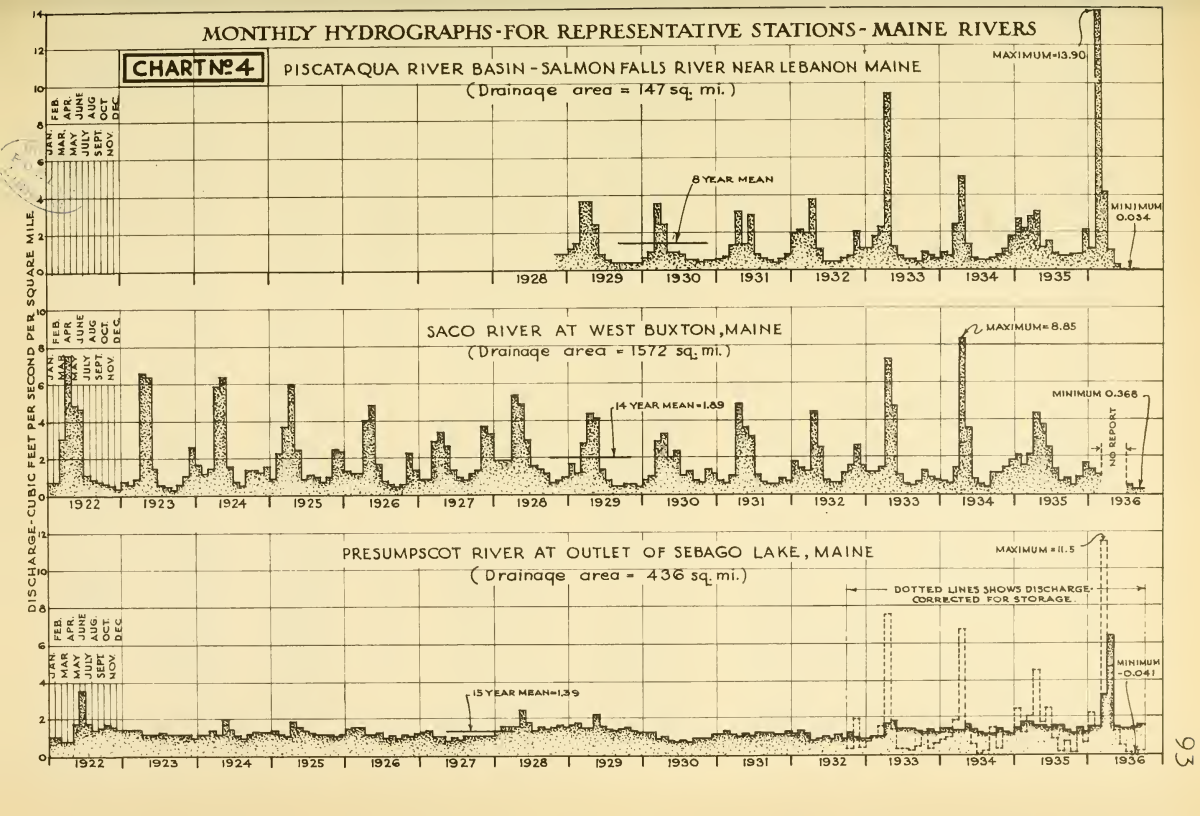
There are no important tributaries to the Presumpscot River other than the Crooked River mentioned above.

Discharge is recorded at a gaging station at the outlet of Sebago Lake. The records for this station are summarized in Table III-A.

The hydrograph on Chart 4 shows the average monthly runoff during the past 15 years at Sebago Lake outlet. The average regulated runoff from the drainage area of 436 square miles above this station is 1.47 cubic feet per second per square mile.

HUMAN OCCUPANCY

Population The population of this basin in 1930 was slightly over 24,000, exclusive of a small section of Portland which is drained by the Presumpscot River, but which it is more logical to treat when Portland is discussed as a whole in the Maine-New Hampshire Coastal Basin chapter. The population was practically stationary from 1920 to 1930. Because there are extensive woodlands in the north, that portion is thinly inhabited; hence the average density of population in the basin is only 40 per square mile.


MONTHLY HYDROGRAPHS-FOR REPRESENTATIVE STATIONS-MAINE RIVERS
CHART No. 4
PISCATAQUA RIVER BASIN-SALMON FALLS RIVER NEAR LEBANON MAINE
(Drainage area = 147 sq. mi.)
MAXIMUM=13.90
8 YEAR MEAN
MINIMUM 0.034
SACO RIVER AT WEST BUXTON, MAINE
(Drainage area = 1572 sq. mi.)
MAXIMUM= 8.85
14 YEAR MEAN=1.89
MINIMUM 0.368
NO REPORT
PRESUMPSCOT RIVER AT OUTLET OF SEBAGO LAKE, MAINE
(Drainage area = 436 sq. mi.)
MAXIMUM = 11.5
DOTTED LINES SHOWS DISCHARGE CORRECTED FOR STORAGE.
15 YEAR MEAN=1.39
MINIMUM 0.041
DISCHARGE-CUBIC FEET PER SECOND PER SQUARE MILE
JAN. MAR. MAY JULY SEPT NOV
FEB. APR. JUNE AUG OCT DEC
1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936

Only three towns have more than 2500 inhabitants - Westbrook, 10,807, Gorham, 3035, Bridgton, 2659; small portions of these communities lie in adjacent basins. About a third of the population is in small villages or on farms, mostly in the lower part of the basin.

The net growth in population between 1920 and 1930 practically paralleled that of the adjacent city of Portland, which had an increase of only about 2%. Westbrook, however, increased 14%, due apparently to its activity in manufacturing. Past trends indicate that future growth will be slow and will occur in the lower part of the basin.

Agriculture Farm land comprises about two-fifths of the area and of this about one-fourth is wooded. Farm land value in Cumberland county is considerably higher than the average for the state. Proximity to Portland and ready access to population points outside of the state, in addition to the market created by the summer population, contribute to the value of farming interests. The value of farm products in 1930 was about $5,000,000, of which the greater part was derived from dairy and poultry products. Because the land is fertile and the market conditions favorable, agricultural activity may be expected to increase in the Presumpscot basin.

Industry Pulp and paper manufacturing is the most important industry, but there are also several small textile, lumber and miscellaneous manufacturing plants in the lower part of the basin. These were originally attracted by the water power produced on the main river. The value of paper and other products manufactured at Westbrook and other points in 1933 was about $7,500,000.

Industrial activity in this region is dependent largely upon the paper mills, as they employ over half of the industrial workers. Since the power sites of the river are almost fully developed, and since industries were originally attracted to the region by the water resources for power and processing, it is probable that future developments will come in the field of small establishments for which there is an ample supply of purchasable power.

Mining The only granite quarry is in Westbrook, and there are no other commercial mining operations.

Lumbering Much white pine has been cut in the past; but since the mature growth of this species has been depleted, the principal timber resource is hardwood which supplies several wood-working establishments. Paper mills located in the region secure their supply of pulpwood from outside points.

As there is practically no pulpwood in the basin, which is so plentiful in many Maine watersheds, lumbering will probably be confined to the cutting of hardwoods for wood-using industries already established. It is probable also that the present immature growth of white pine will constitute an important supply of merchantable timber.

Recreation Land used for recreation constitutes a larger proportion of the Presumpscot watershed than is the case in any other Maine basin. While the main stream does not now serve intensive recreational purposes,

it could if freed of excessive pollution. The tributary lakes, ponds and streams all serve recreation and wildlife to some extent. At practically all of the lakes, the most popular of which is Sebago, favorable transportation facilities have induced a development of summer colonies which represents a sizeable financial investment.

The headwaters of the Presumpscot system drain a mountainous section where wildlife abounds and the waters throughout the basin tributary to the main stream shelter many species of fish. Deer and small game are numerous, while landlocked salmon, brook trout, bass and waterfowl are also plentiful. The prevalence of such game in this scenic and accessible region has gained for the basin recognition as one of the most favored recreational districts in the state.

Transportation There is no commercial water transportation on the Presumpscot River, nor has the Federal Government ever made any improvements for navigation. Tidewater extends to Presumpscot Falls, about two and one-half miles from the mouth of the river. A portion of this section contains a natural six foot channel.

The highways of this basin are numerous and are in general adequate for the needs of present traffic. Eventually a by-pass in the form of a coastal highway around Portland will probably be needed.

The lower portion of the basin is served by the Boston and Maine Railroad centering in Portland. A Maine Central line runs the length of the basin from Portland to North Conway, New Hampshire. Except in the upper hilly region there are sufficient railway connections.

There are at present no landing fields in this basin, but sea-plane facilities are available on Sebago Lake.

WATER USE AND CONTROL

Pollution The acute pollution problems of the Presumpscot watershed originate on the main river, below the outlet of Sebago Lake. This lake, the source of the largest public water supply system in Maine, provides water of exceptional quality. The area tributary to the Lake, including the Sebago-Naples-Long Lake region, offers unusual recreational attractions which have accounted for the establishment of about 30 boys' and girls' summer camps. Sanitary conditions here undergo constant inspection, and at present the generally satisfactory condition is attested by the purity of Sebago Lake water.

The only significant source of domestic pollution is at Westbrook, where a system serving about 6000 people discharges untreated sewage into the Presumpscot.

The industries in this basin employ approximately 3,200 of which number three pulp and paper plants account for 1800, and textile mills for 660. The wastes from these plants as well as uncollected domestic sewage from many of the mill villages are continuously entering the stream without treatment. Because the stream flow is comparatively small, due

partly to the diversion of water from Sebago Lake for Portland's water supply, the discharge of wastes places a heavy burden on the river.

Undoubtedly the contaminated condition of the Presumpscot retards the local recreational use of the stream, and pollution, augmented by inadequate fishways, accounts for the absence of desirable fish species. The health hazard involved is reduced, however, since the only dense settlement on the seriously polluted part of the river is the city of Westbrook.

Although municipalities and industries are aware of the existing unsanitary conditions, the expense of installing treatment plants has delayed action, although there exists a polluted condition which approaches or exceeds the intensity of that on the Androscoggin River.

A sanitary survey of the Presumpscot would supply necessary technical data for future improvement of present conditions. The survey should cover all factors that may influence recreation, wildlife, industry, or public health.

Water Supply The surface and ground water supply throughout the basin is adequate, and all concentrated communities of over 1000 persons draw upon public supplies. All but five of the supply systems in the watershed are linked to the Portland Water District System, which serves nearly all of the basin south of Sebago Lake as well as several nearby municipalities on the coast. The Portland water system secures exceptionally desirable water from Sebago, its sole source. This system regularly serves municipalities with a resident population, in 1930, of over 100,000 -- one-eighth of the entire population of Maine -- and during the vacation season it serves many summer colonies in addition.

The primary water supply problem of the Presumpscot is the protection of the Sebago Lake source without imposing unnecessary limitations on recreational growth.

Flood Control The large amount of storage on this river reduces flood peaks to a minimum. There has been little or no damage in the valley except on the tributaries, and such damage as has occurred has been insignificant. No opportunity exists for any material increase in storage except by raising the levels of lakes and ponds and this would result in high flowage damages. It may therefore be concluded that additional measures of flood control on this basin are not economically justified.

Power The Presumpscot River is a natural power stream due to the large amount of storage in the Sebago Lake system and the steep fall of the river, about 266 feet in 22 miles, or 12.1 feet per mile. The river is completely developed between Sebago Lake and tidewater, with 9 installations totalling 21,965 horsepower and a total head of 249.5 feet.

The only plants with installations of 1000 horsepower or over are on the main river below Sebago Lake. They are, beginning near the

mouth and going upstream:

Location of Plant	Wheel Capacity, H. P.
Smelt Hill	1000
Cumberland Mills	2040
Saccarappa	2445
Mallison Falls	1430
Little Falls	2100
Gambo Falls	2030
Dundee Falls	5000
Great Falls	2920
Eel Weir	3000

The remaining developments, with capacities ranging from 100 to 520 horsepower, are on Crooked River, Stevens Brook and the Piscataqua River. The total installation at these plants is 1232 horsepower.

The grand total of the main river and tributary installations amounts to 23,197 horsepower. Most of this power is used for lumber manufactures, only 4870 horsepower being utilized by hydro-electric plants.

As noted above, an outstanding feature of this river is its storage. The 1918 report of the Maine Water Storage Commission lists 69 lakes and ponds in the watershed, with a combined water surface of 81 square miles, or 13.1% of the basin area. Ninety percent of the water surface is provided by the Sebago Lake system. The total volume of storage, 321,000 acre-feet, is utilized by the nine plants on the river.

The development of power on the river has been carried to the economic limit and no further opportunities for development exist. The remodelling of existing plants might increase the power output of the river, but such increase would be comparatively small.

Navigation Tide-water extends to Presumpscot Falls, about two and one-half miles from the mouth of the river. A natural six-foot channel exists in a portion of the tide-water section. This tide-water section is now being investigated to determine if improvement of the channel is warranted.

Erosion Slight sheet erosion with occasional gullies occurs in several parts of the watershed, but moderate sheet erosion is confined to one small area north of Westbrook.

Drainage As in the Androscoggin Basin, swamp areas are confined here to land pockets or lakes, pond and stream shores. No drainage of these sections is necessary except in a few places where the mosquito nuisance is obnoxious.

Recreation The southern section of the basin might serve local recreation to a greater degree than it now does, but to achieve this near the cities of Westbrook and Portland, where it is most needed, would entail not only elimination of pollution, but also restriction of industrial use of the river. Throughout the area there is urgent need of preserving the balance between sanitation requirements and those of recreation and wildlife.

SACO BASIN

GENERAL DESCRIPTION

The Saco basin has a drainage area of 1730 square miles, of which 830 square miles are in Maine and 900 in New Hampshire. The basin is about 70 miles long and, at maximum, 45 miles wide. The river rises in the White Mountains and flows southeast for a distance of 30 miles to the New Hampshire-Maine boundary line and thence continues southeast for 80 miles to the head of tidewater at Biddeford, five miles above its mouth.

The headwaters region is high and rugged, with very steep valley and river slopes. The topography is rolling in the mid-portion of the basin, and fairly level near the coast. The river falls rapidly in the New Hampshire part of its course, then falls only 173 feet in the first 62 miles below the state line, and finally drops 221 feet in the 19 miles between Bonny Eagle Dam and tidewater.

The general rock formation is granite, with some limestone and schist; the soil cover is glacial sand and gravel. Much of the area is forested, primarily with conifers, but in the lower portions of the basin, large areas have been cut over and are re-seeding to hardwoods. About 10% of the basin, mostly in the level river valleys and the lowlands near the coast, is in crop or pasture land.

The average annual rainfall ranges from 36 inches near the coast to 46 inches in the interior and reaches as high as 82 inches at the summit of Mt. Washington. The rainfall is fairly well distributed throughout the year, although it is slightly greater in summer than in the other seasons. The summer temperature averages about 66° except in the mountains, where it is somewhat lower. Average winter temperatures vary from 15° to 25°, depending on altitude and latitude.

Ossipee River, the principal tributary, flows out of Ossipee Lake, which is fed by streams rising in the Sandwich and Ossipee Mountains. Its length, between Ossipee Lake and its junction with the Saco River at Cornish, Maine, is about 20 miles. Ossipee Lake, the largest body of water in the Saco basin, has a water area of 6.1 square miles and controls 327 of the 455 square miles in the Ossipee River basin.

Records of stream flow at Center Conway, Cornish, and West Buxton gaging stations are kept by the U. S. Geological Survey in cooperation with the states of Maine and New Hampshire. These records are published in the U. S. Geological Survey Water Supply Papers, Part I - North Atlantic Slope Basins. The figures in Table III-A are summarized from unpublished records of the U. S. Geological Survey as well as from the Survey's published Papers.

The hydrograph on Chart 4 shows the average monthly runoff during the past 15 years at West Buxton on the Saco River. The average runoff from the drainage area of 1572 square miles at this station is 1.88 cubic feet per second per square mile.

HUMAN OCCUPANCY

Population In 1930 the Saco basin had a population of 48,500, about 3% less than that in 1920. Four-fifths of the inhabitants are in Maine. The average population density of the basin is about 28 per square mile; of the Maine portion, 45 per square mile; of the New Hampshire portion, 10 per square mile.

Only three towns in the watershed have over 2500 population: Biddeford (pop. 17,633), Saco (pop. 7,233), and Conway (pop. 3,217). The first two of these towns, at the outlet of the Saco River on the Maine coast, account for half of the entire population of the basin. Of the remaining towns, one, Buxton, has over 1500; four have between 1000 and 1500 inhabitants; and the others are small villages.

Population in the 1920-1930 decade decreased about 3% as contrasted to the 4% gain for the state of Maine. The small decrease at Biddeford was offset by an equal gain at Saco. Gains and losses of all communities are indicated on Map 7. The future trend will probably depend upon the success of manufacturing interests.

Agriculture About one-third of the area is in farm land, and of this a large portion is woodland. The soil fertility is not high, as is indicated by an acreage value slightly under the average for the state of Maine. The value of agricultural products, about one-half of which was derived from dairy and poultry operations, was in 1930 about $3,000,000. Woodlots contributed a small part of farm revenue. There is no indication of marked changes in agricultural conditions except possibly a continuing trend toward specialized activities, such as poultry raising.

Industry Biddeford and Saco, the industrial centers of the region, produce cotton textiles, textile machinery and shoes. Cotton manufacturing gives employment to two-thirds of the workers. The value of products manufactured at Biddeford in 1933 was about $14,000,000.

Labor troubles in Biddeford have at times caused apprehension concerning the continuance of some of the industries. If satisfactory industrial relations obtain in the future, moderate growth in manufacturing will result.

Mining The only mining operations in this basin have been the quarrying of small amounts of granite in the vicinities of Hollis and Fryeburg.

Lumbering Unlike most of the Maine river basins, the Saco produces no pulpwood. This is accounted for by the fact that it lies in the white pine rather than the spruce belt. The amount of lumbering carried on is at present comparatively small because of the immature growth of the pine stands. In the lumber industry the trend appears to be toward the development of existing young forests which will in time produce merchantable pine. The nearness of the region to wood-using markets is a factor favorable to the production of lumber.

Recreation The territory at headwaters and at the mouth of the river are the only sections of the basin which have been intensively developed for recreational use. The New Hampshire tributaries drain precipitous White Mountain slopes, while in Maine the tributary scenic lakes lie in hilly terrain. These characteristics make the region ideal for summer homes and children's camps. At the mouth of the river, the summer population has occupied nearly all the ocean front.

In the central part of the watershed, except for scattered lakes and two major canoe routes, the principal recreation value depends upon wildlife. Nearly all types of native wildlife except moose and bear are to be found in large numbers; a fishway at Biddeford facilitates fish migration into the valley streams.

Transportation Although the Saco River has an 8-foot channel at mean low water to Saco and Biddeford, about five miles from the ocean, commercial transportation is hampered by the fact that the railroad line through these cities does not connect with the wharves.

The basin is provided with a system of main and secondary roads which meets most traffic requirements. However, improvement of the main arteries across the southern end of the basin and those into the upland recreation area is needed.

The lower end of the basin is crossed at Biddeford and Saco by the main line of the Boston and Maine Railroad from Boston to Portland. Additional service is provided by the mountain division of the Maine Central from Portland to St. Johnsbury, Vermont, and by the Conway branch of the Boston and Maine from Portsmouth.

Existing landing fields are located at Biddeford, West Baldwin, Freedom and North Conway. During the summer of 1936 there was regular week-end air service between North Conway and New York, but to date there has been no other scheduled air service to points in the Saco basin.

WATER USE AND CONTROL

Pollution The major part of the pollution of the Saco River is caused by the domestic sewage and industrial waste discharge from the twin cities of Saco and Biddeford, which have a combined population of 24,800, 73% of the population in the Maine section of the basin. In these cities textile plants employing 3700 persons, and boot and shoe plants employing 800 are the chief sources of the river's industrial pollution. The detrimental effect of this contamination is felt not only in the immediate vicinity of the two cities but also, more acutely, at summer resorts along the shore, particularly Biddeford Pool, Old Orchard Beach and Prout's Neck.

Above Saco and Biddeford pollution problems are minor, and of local significance. Both domestic and industrial wastes discharged into the river from New Hampshire sources are small and probably negligible.

Water Supply Surface and ground water supplies are normally abundant throughout the drainage area. The nine Maine towns in the basin which are served by public systems include all the communities of over 200 houses. The sources of supply are evenly divided between springs, wells and streams. The largest towns, Biddeford and Saco, are served by water taken from the lower reaches of the Saco River and treated by coagulation, filtration and chlorination. Extension of established systems, or construction of new ones, will eventually be required to meet the needs of growing summer colonies. Future surface supplies in the Maine area may require filtration, because most of the available watershed areas are developed for agricultural and residential use to such an extent that the water supplies may be contaminated.

In the New Hampshire portion there are several public surface supplies, none of which is treated. According to the 1936 Report of the State Board of Health, the quality of the water from the supplies serving Bartlett and Conway is so unsatisfactory as to make installation of treatment plants.... advisable.

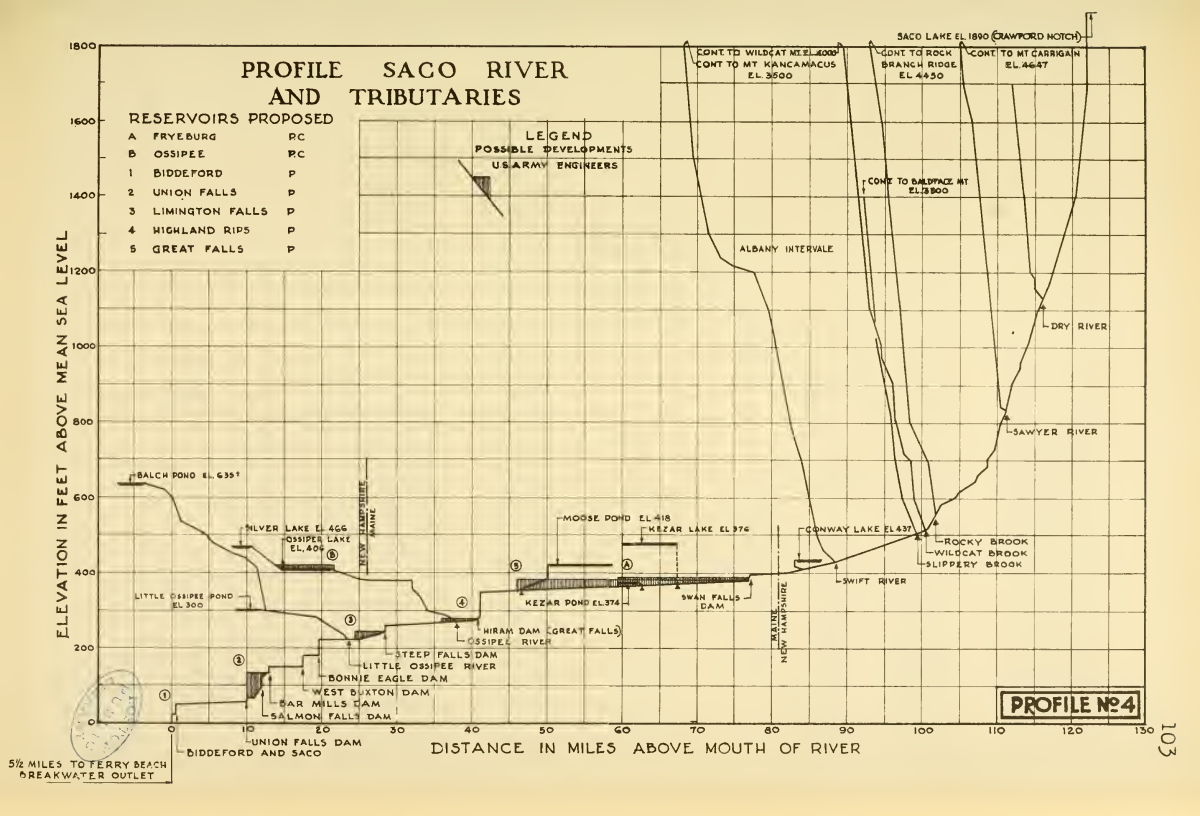
There are innumerable sources of pure water supply in the New Hampshire section of the basin.

Flood Control In the past 60 years there have been six high floods. The last four have occurred in the period during which records have been kept by the U. S. Geological Survey at West Buxton, Maine. Of these four, the 1936 flood, by far the greatest, amounted to 58,200 cubic feet per second peak discharge and caused damages, as determined by the U. S. Army Engineer, of $1,610,000, divided between $1,192,000 for direct damages and $418,000 for indirect damages. The principal damage was the destruction of highway bridges, entailing losses amounting to over $400,000. Industrial, commercial and public utility losses amounted to another $400,000.

The 1923 flood was the second largest on record, the maximum discharge being 27,800 cubic feet per second. The 1927 flood which did so much damage on the Vermont rivers does not fall in the list of the four highest in the Saco Basin. The 1896 flood, the discharge of which is estimated to have been 40,000 c.f.s. at Biddeford, was greater than the 1923 flood but less than the 1936 flood; the resulting damage was well below $500,000. Spring floods caused by heavy rainfall and melting snow are most likely to yield maximum discharges.

From a study of the possibilities of flood control reservoirs in the valley made by the U. S. Army Engineers and reported in House Document #659, 71st Congress, 3rd Session, the Engineers concluded that although flood control reservoirs are the most practicable means of preventing floods, the possible benefits from a system of such reservoirs would be out of proportion to the cost of building and maintaining them.

The 1936 investigations by the Army Engineers disclosed that the two best reservoir sites were above Hiram and at Ossipee Lake, as noted in the following section.


PROFILE SACO RIVER AND TRIBUTARIES
RESERVOIRS PROPOSED
A FRYEBURG RC
B OSSIPEE RC
1 BIDDEFORD P
2 UNION FALLS P
3 LIMINGTON FALLS P
4 HIGHLAND RIPS P
5 GREAT FALLS P
LEGEND
POSSIBLE DEVELOPMENTS
U.S. ARMY ENGINEERS
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DISTANCE IN MILES ABOVE MOUTH OF RIVER
SACO LAKE EL 1890 (CRAWFORD NOTCH)
CONT TO WILDCAT MT EL 4000
CONT TO MT KANCAMACUS EL 3500
CONT TO ROCK BRANCH RIDGE EL 4450
CONT TO MT CARRIGAIN EL 4647
CONT TO BALDFACE MT EL 3800
ALBANY INTERVALE
DRY RIVER
SAWYER RIVER
ROCKY BROOK
WILDCAT BROOK
SLIPPERY BROOK
CONWAY LAKE EL 437
SWIFT RIVER
MOOSE POND EL 418
KEZAR LAKE EL 376
KEZAR POND EL 374
SWAN FALLS DAM
HIRAM DAM (GREAT FALLS)
OSSIPEE RIVER
STEEP FALLS DAM
LITTLE OSSIPEE RIVER
BONNIE EAGLE DAM
WEST BUXTON DAM
BAR MILLS DAM
SALMON FALLS DAM
UNION FALLS DAM
BIDDEFORD AND SACO
5½ MILES TO FERRY BEACH BREAKWATER OUTLET
BALCH POND EL 635?
MYER LAKE EL 466
OSSIPEE LAKE EL 400
LITTLE OSSIPEE POND EL 300
NEW HAMPSHIRE MAINE
MAINE NEW HAMPSHIRE
PROFILE №4

Power The existing developments on the Saco River have a total installation of 39,291 horsepower, of which 37,046 horsepower are on the main river and 2,245 on the tributaries. Between the Maine-New Hampshire boundary and tidewater 226 of the 394 feet of head available on the main stream are utilized. In addition to the existing power, there are 25,430 potential horsepower in the river system, divided between 21,740 horsepower on the main river and 3690 on the tributaries.

The two largest installations are the Bonny Eagle plant (wheel capacity, 14,400 horsepower) and the West Buxton plant (wheel capacity, 11,160 horsepower). Both of these plants are used for generating electric power. Ninety-one per cent of the power, or 35,896 horsepower, is developed by public utilities; the remainder is used by textile and lumber mills.

The present developments of 1000 horsepower or over, all of which are on the main river in Maine, as listed by the U. S. Geological Survey as of January 1, 1937, are:

Location of Plant	Wheel Capacity, H.P.
Biddeford	1050
Biddeford	1473
Union Falls	1000
Bar Mills	1788
Bar Mills	1275
West Buxton	11,160
Bonny Eagle	14,400
Hiram Falls	3750

The above-named capacities total 35,896 horsepower. The remaining 3395 horsepower are developed by 11 plants with wheel capacities ranging from 100 to 950 horsepower. The four largest of these 11 are hydro-electric plants which, together, develop 2325 horsepower.

As the best sites on the river have been utilized, and as there is but a small amount of storage to provide for low water regulation, there is little likelihood of economical development of additional power. The best opportunities for obtaining additional power lie in the re-development of existing plants, as at the Biddeford-Saco site, where the Cumberland County Power and Light Company is now constructing a new dam and hydro-electric plant which will develop an average operating head of 44 feet. The capacity of the Kaplan propeller type water wheel which is to be installed will be 9000 horsepower.

Four other sites are listed by the Army Engineers in House Doc. 659, 71st Congress, 3rd Session as being worthy of consideration for development or re-development:

Location	Head-ft.	Horsepower
Re-development		
Great Falls	75	5950

Location	Head-ft.	Horsepower
New Developments		
Union Falls	70	10,000
Limington Falls	21	2,100
High Rips	14	1,650

It may be feasible to redevelop the Great Falls site, destroyed by fire and flood in 1936, to produce 2200 horsepower under a head of 17 feet.

Although there are approximately 120 lakes and ponds tributary to the Saco system, they are so small that their combined water surface is only 43 square miles, 2.5% of the basin area. Ossipee Lake is the largest, with 6.1 square miles, and Kezar Lake, in Maine, the nest largest, has a water area of 3.9 square miles. The total storage in the basin is about 85,000 acre-feet.

According to Maine Water Storage Commission report (1918), about 317,000 acre-feet of additional storage can be obtained, of which 229,000 acre-feet would be in a reservoir located 2 miles above the town of Hiram.

Investigations have recently been made by the U. S. Army Engineers to determine the flood storage possibilities in the river. Two sites appeared to offer the greatest advantages: the one above Hiram (referred to by the Engineers as the Fryeburg reservoir) and another at Ossipee Lake. The Fryeburg site afforded the best opportunity for combined storage for power and flood control.

The Engineers estimated that if power storage were provided in the Fryeburg reservoir, a low water flow of 1,220 cubic feet per second could be obtained, and that this would be capable of producing, annually, approximately 21,000,000 kilowatt-hours of primary energy at a power development just below the dam. The additional annual output of primary energy at the existing downstream plants would be 17,000,000 kilowatt-hours, and if the potential power were developed, the total output on the river would be increased by 65,000,000 kilowatt-hours.

Without any power development at the reservoir, the storage would be available for an increased low water flow which would produce an additional 44,000,000 kilowatt-hours of primary energy annually. Adding to this the potential power at undeveloped sites, the total annual output could be increased to 87,000,000 kilowatt-hours. One hundred twenty-seven feet of the total 213 feet of developed head below the site have sufficient capacity to benefit from increased low flow. This head includes the re-developed head of 44 feet at Biddeford.

If the Fryeburg reservoir were constructed primarily as a flood control reservoir, and the reservoirs were assumed to be half filled at the beginning of the dry season, the increased low-water flow of the river at West Buxton would be as follows: with Fryeburg reservoir alone, 538 cubic feet per second; with Ossipee Lake reservoir alone, 238 cubic feet per second; and with both Fryeburg and Ossipee Lake reservoirs, 668 cubic feet per second.

The corresponding annual power benefits to existing plants provided by this increased flow would be: with Fryeburg reservoir alone, 12,000,000 kilowatt-hours; with Ossipee Lake reservoir alone, 4,000,000 kilowatt-hours; with both reservoirs, 16,000,000 kilowatt-hours.

Navigation A channel with a project depth of 8 feet extends 5 or 6 miles upstream to the twin cities of Saco and Biddeford. Traffic, in 1935, amounted to 20,760 tons of freight, of which petroleum was the largest single item. Some shoaling has occurred in this channel and restoration of project depths has been scheduled for the spring of 1938. This will probably meet the needs of water transportation on the Saco River unless, at some future time, the railroad line through Biddeford and Saco is connected with the wharves.

Erosion Along the larger streams of the Saco basin there is slight sheet erosion, usually accompanied by occasional gullying. In two relatively small areas, near West Buxton and near Biddeford, erosive action has carried away at least 25% of the top-soil, but in no parts of the basin may erosion problems be termed serious.

Drainage The advantage of conserving the wildlife of swamps, bogs and marshes as opposed to the desirability of eliminating the mosquito pests of these areas has prompted caution in specifying drainage proposals. In many localities, it is believed that the reduction of the local mosquito nuisance will compensate for the loss of wildlife disrupted by limited drainage. In the cities of Saco and Biddeford, 70 and 150 acres, respectively, of salt marsh have been indicated as areas where drainage is justified because of the large summer population located in the coastal sections of these municipalities. The effectiveness of these small drainage activities will demonstrate the limits within which it is feasible to operate large drainage projects.

Recreation The intensive recreational use of the ocean shore and tributary headwater areas warrants protection of recognized vacation sites. The effects of pollution and water levels upon recreational attractiveness should be thoroughly investigated before measures of sewage disposal, flood control, or power development are undertaken.

PISCATAQUA BASIN

GENERAL DESCRIPTION

The Piscataqua River is a tidal estuary extending northwestward from the ocean for about 12 miles. Into this estuary, or its tidal arm, Great Bay, flow the Salmon Falls, Cocheco, Lamprey, and Exeter Rivers, as well as numerous smaller streams. The Piscataqua and its chief tributary, the Salmon Falls, constitute the lower 35 miles of the Maine-New Hampshire boundary line. The other three tributaries named are all in New Hampshire.

The Piscataqua Basin is about 45 miles long, from north to south, and has a maximum width, east to west, of 30 miles. The total drainage area above the mouth is 1,030 square miles, of which 240 are in Maine and the remainder in New Hampshire. Total water surface, except for large tidal expanses, is only about 16 square miles, 1.5% of the total drainage area.

The basin is irregular in the northern portion, and elsewhere low and rolling. The Salmon Falls River, with a total fall of 560 feet, is by far the steepest tributary of the four. Rock formation is granite, and soil covering is mostly glacial sand and gravel. Twenty per cent of the area is cleared farm land; the remainder of the basin, exclusive of urban areas, is covered with second-growth forest land.

Mean annual rainfall in the basin is about 39 inches, evenly distributed throughout the year. Summer temperature averages about 66°, and winter temperatures vary with proximity to the coast, from 26° to 20°.

Of the four principal tributaries of the Piscataqua, the Salmon Falls River drains the largest area, 340 square miles. Flowing south along the state line from source to mouth, the river is about 32 miles long and drains an area about the same length and roughly 1/3 as wide.

The Cocheco River rises just southeast of Lake Winnepesaukee, and flows southeast a distance of about 35 miles, joining the Salmon Falls River 3 miles below Dover to form the Piscataqua. The total area drained by the Cocheco is about 220 square miles.

The Lamprey River rises in northern Rockingham County and flows, first south, then east, a total of about 40 miles to Great Bay. The area drained by the Lamprey comprises about 180 square miles of the most thinly-settled part of southeastern New Hampshire.

The Exeter River rises about 15 miles east of Manchester, New Hampshire, and flows east, then north, about 30 miles through comparatively low country to Great Bay. It drains a total area of somewhat over 100 square miles.

During the past 8 years the U. S. Geological Survey has kept discharge records at a gaging station on the Salmon Falls River near Lebanon, Maine. Detailed data for the flow at this station may be found in the U. S. Geological Survey Water Supply Papers, Part I - North Atlantic Slope Basins. The figures in the Table III-A are summarized from unpublished records in the office of the District Engineer at Augusta and from the published papers of the Survey.

The hydrograph on Chart 4 shows the average monthly runoff during the past 8 years at Lebanon. The average runoff from the drainage area of 147 square miles, over this period, is 1.40 cubic feet per second per square mile.

HUMAN OCCUPANCY

Population This basin in 1930 had a population of 87,000, practically the same as that in 1920. Nearly three-fourths of the inhabitants are in New Hampshire. The density is relatively high, about 85 per square mile as contrasted to 28 in the Saco River basin adjoining. More than 70% of the entire population is in the ten cities and towns of over 2500 people, viz.:

Portsmouth,	N.H.	14,495
Dover,	" "	13,573
Sanford,	Maine	13,392
Rochester,	N.H.	10,209
Somersworth,	" "	5,680
Exeter,	" "	4,872
Kittery,	Maine	4,400
Farmington,	N.H.	2,698
So. Berwick,	Maine	2,650
Newmarket,	N.H.	2,511

Only about 20% of Sanford is in the Piscataqua watershed, the remainder being in the watershed of the Mousam River, one of the Maine-New Hampshire coastal group. Portsmouth, an important trading center, is the seaport of New Hampshire. Portsmouth Navy Yard, "the only navy yard in New Hampshire," is actually in Kittery, Maine on Portsmouth Harbor. Dover, Sanford, Rochester and Somersworth are important manufacturing and business centers.

In the 1920-1930 decade, when population increased in Maine nearly 4%, and in New Hampshire 5%, there was almost no increase in population in the Piscataqua basin. Of the ten towns having over 2500 population, only four--Somersworth, Kittery, South Berwick and Newmarket--decreased; the entire group of ten towns had a net increase of 4%. Future population changes will probably be in proportion to the increase or decrease in industrial activity.

Agriculture Agriculture in this region is largely of a specialized type, with farms somewhat smaller than the average farm in Maine and New Hampshire one-third of the total farm revenue is derived from poultry and about one-fourth from dairying. On account of the fair quality of the soil in certain sections and the proximity to large markets, the 1930 value of farm land and buildings was $62 per acre in Rockingham County and $50 in Strafford County. (These two counties include fully three-fourths of the territory in the Piscataqua basin.) According to the U. S. Census of Agriculture, the farm revenue in the Piscataqua basin in 1930 was about $6,000,000.

In this region the trend is toward a continuance of specialized farming, especially poultry production. The raising of fruit and other products that find a ready market in the near-by population centers is becoming an important part of farm activity.

Industry Industrial activity includes several lines of manufacturing - shoes, textiles, wood products and many miscellaneous types. In 1933 the value of products manufactured in Strafford County, which includes Dover, Rochester and Somersworth, was over $21,000,000. Those parts of Rockingham and York counties within the Piscataqua basin accounted for about $12,000,000.

On account of the diversified character of manufactures and the evident trend toward further diversification, it is probable that a moderate increase in manufacturing activity will continue in this basin.

Mining Although the rock structure of most of the basin is granite, comparatively little quarrying is carried on. Clay deposits near Epping have made that town famous for its brick. There is, however, no reason to believe that there will be any increase in mining activities.

Lumbering This region is in the white pine belt, but there is a relatively small percentage of marketable timber. There are extensive areas of young growth of both pine and hardwood that assure a substantial supply of raw material for wood-using industries.

Recreation Along the shores of the Piscataqua River and Great Bay, as well as on the shores of the few ponds near the headwaters, summer cottages are to be found in great numbers. Except on the ocean and ponds the primary recreational value of the basin lies in wildlife, the supply of which would normally be plentiful, because the region is a naturally favorable habitat for many fish and game species. However, hunters and fishermen from nearby population centers have reduced the numbers to a point where wildlife may, from the recreational standpoint, soon cease to be an asset.

Transportation The Piscataqua River proper has not been improved for navigation beyond the railroad bridge at Portsmouth. There is, however, a natural channel depth of about ten feet from Portsmouth to the junction of the Cocheco and Salmon Falls rivers at the upper end of the tidal estuary and the channels of the Exeter, Lamprey, and Bellamy Rivers, flowing into Great Bay and thence into the Piscataqua, as well as that of the Cocheco River, have been improved.

There is a good system of highways in the basin. Nevertheless, the construction of a new bridge across the Piscataqua and a by-pass around Portsmouth to eliminate traffic congestion on Route U. S.#1 is now being considered by an Interstate Bridge Commission; and the New England Regional Planning Commission has recommended construction of a freeway across the eastern part of the basin and redevelopment of the arterial highway running north from this freeway toward the White Mountains.

Railway service is provided by two lines of the Boston and Maine Railroad between Boston and Portland, one of which crosses the basin through Exeter and Dover, and the other through Portsmouth and Kittery. The northern end of the valley is served by a Boston and Maine line from Dover through Rochester to North Conway, New Hampshire.

There is at present no scheduled air transportation to or from any point in this basin. The municipal landing field in Portsmouth is, however, included in the designated route of U. S. Civil airway #9 from Boston to Bangor and Bar Harbor.

WATER USE AND CONTROL

Pollution There are sewer systems in New Hampshire cities and towns which have a total population of 45,250; this is 65% of the entire population in the New Hampshire portion of the basin. Of the eight communities having sewerage facilities, Dover, which discharges its raw sewage into the Cocheco River, is the only one without treatment works. One community treats its sewage by means of an Imhoff tank; two, by septic tanks; 4 by sand filters.

Over half of the population of 11,500 in the Maine portion of the basin lives along the tidal estuary composing the lower Piscataqua. Kittery, near the coast (pop. of 4400), has a sewer system and discharges untreated sewage into tidewater. The other Maine communities of the basin are without public sewer systems.

In addition to domestic sewage, the river and tributaries receive large quantities of industrial wastes from various manufactories, principally woollen textile plants. While the Maine cities of Berwick and South Berwick are responsible for pollution from woolen wastes, the larger industrial centers of Dover, Rochester and Portsmouth contribute a higher degree of pollution, and it is for these cities that corrective measures should first be considered.

Water Supply The surface and underground water supply in the basin is adequate for existing needs as well as for future supplies. In general, water taken from surface sources requires treatment before use.

Eleven communities in New Hampshire have water supply systems. Several purification plants are installed where water is taken from surface sources, and over one-half of the supplies receive chlorination. Dover and Portsmouth, the largest communities, use wells as their sources of supply.

Maine communities in the basin derive practically all their water from surface sources, and in all but one instance the water is chlorinated. Lebanon, with a population of 1148, is the only large community without a public water supply.

Flood Control The series of ponds in the upper end of the basin and the Milton Ponds, midway along the course of the river, provide a retarding influence on floods. Although these water areas are not large in proportion to the basin area, they are effective in times of high water.

Owing to the deep narrow valley of the river and the small areas of low borderland along the river, flood control is not urgently needed in the Salmon Falls River. The territory drained by the other tributaries is so flat that runoffs are too slow to assume flood proportions.

The flood of 1936 was the highest on record. Near South Lebanon, Maine, there was recorded a peak discharge of 5,490 cubic feet per second, equivalent to a unit discharge of 37.3 cubic feet per second per square mile. This was much lower than the unit discharges for the same flood on other New England rivers of equal size.

The present storage controls only a small part of the total area, and the lake and pond area is only 1.5% of the total basin area. Great East Pond, the largest lake, has storage of 20,000 acre-feet in the top ten feet, and its water surface is about 2.6 square miles. The Milton Ponds have a storage of about 8,500 acre-feet in the top ten feet and a water area of 1.3 square miles. Bow Lake and Pawtuckaway Pond, with areas of 1.8 and 1.4 square miles, respectively, are the only other water bodies of more than a square mile in area. Although these lakes and ponds contain relatively small amounts of storage, their location in the river system is such as to be effective in retarding flood flows.

The Army Engineers found, in the course of their 1936 investigation, that there is a possibility of increasing the available storage by constructing two additional reservoirs, at Milton and Berwick. The estimated storage of the Milton reservoir would be 43,000 acre-feet, and of the Berwick reservoir from 40,000 to 53,000 acre-feet.

The greater portion of the flood damage in 1936 occurred below the Milton site and would have been reduced had there been a reservoir here. It is estimated by the Army Engineers that the Milton reservoir would have reduced the 1936 flood peak at Lebanon from 5,500 to 2,400 cubic feet per second and would have reduced the flood level by about 5 feet, bringing it to a point at which no flood damage would have resulted. Even a peak flow of 8,500 cubic feet per second, occurring without the reservoir, would have been reduced to a point where no damage would have resulted.

The investigations by the Army Engineers revealed that the total flood damage in the 1936 flood did not exceed $8,000.

Flood benefit estimates have not been worked out for these reservoirs, but it is doubtful if their construction can be shown to be economical in view of the small amount of damage which has occurred on the river during past floods.

Power The Piscataqua River, being tidal, has no power developments; however, there is a total of 19,135 horsepower installed on the tributaries. The Salmon Falls River has several steep falls that at one time were developed for power which was used mostly by small manufacturing establishments. Present developments have an installed capacity of 14,140 horsepower developed at 10 plants, under a combined head of 371 feet. The remaining power of the Piscataqua basin is developed at 6 plants on the Cocheco River and seven plants on various other tributaries. Hydro-electric plants have installations totalling 8860 horsepower.

The developments of 1000 horsepower or over on the tributaries of the Piscataqua, listed by the U. S. Geological Survey, as of January 1, 1937, are:

River	Location of Plant	Wheel Capacity H.P.
Salmon Falls River	So. Berwick, Maine	1800
Salmon Falls River	Salmon Falls, N. H.	3000
Salmon Falls River	Great Falls (Lower) N.H.	2400
Salmon Falls River	Great Falls (Upper) N.H.	3500
Salmon Falls River	Milton, N. H.	1470
Cocheco River	Dover, N. H.	1400

The total installed capacity in the above list is 13,570 horsepower. The remainder of the existing developments, with capacities between 100 and 800 horsepower, have installations totalling 5,565 horsepower.

The present demand for power in the basin can be fully met by these supplemented by power from public utility companies located in adjacent basins which can transmit their power economically to any part of the Piscataqua basin. In view of this fact, it is doubtful if the development of additional power on the river will be economically feasible for some time to come.

There are no extensive storage areas in the basin, and this condition, coupled with the small natural discharge of the river, prohibits large power installations. Any increase in storage will very likely have to be made by raising the water levels of existing ponds. There are two possible sites where an increase in storage might be obtained, Great East Pond and Milton Pond, both on the Salmon Falls River. The raising of water levels here would result in excessive damage claims, owing to the general use of these lakes and ponds for summer cottages.

Navigation Portsmouth Harbor, the outlet of the Piscataqua River, carried in 1935 traffic comprising 8,103 passengers and 317,498 tons of freight. Over half of the freight was coal. The controlling depth of the channel to the Memorial Bridge at Portsmouth is about 30 feet. Above this point there is no commercial navigation and the controlling depths vary greatly.

Erosion Moderate sheet erosion appears in a small area along the river north of Rochester, and in a larger area near Dover there is moderate sheet erosion with occasional gullies. In the southeastern part of the basin a rather large area suffers slight sheet erosion and another area on the Maine side of the outlet is similarly affected. Slight wind erosion is active along the river in small areas near Berwick, and Eliot, Maine. These erosion problems are purely local and are of land use rather than water resources significance.

Drainage It has been suggested by the Maine State Entomologist that 750 acres of Kittery salt marshland be drained. Relief from the pest will more than counterbalance wildlife values lost, provided drainage control is applied only to areas near settled communities.

Recreation Great Bay, the tidal arm of the Piscataqua, would be of far greater recreational value than it now is if it were not for the amounts of waste discharged into it or forced into it by tidal action, and if it were not for the expanses of mud flats exposed at low tide. To date no practical plan for controlling the water level of Great Bay has been devised.

The only other water-recreation problem in the basin arises from the fact that lakes and ponds normally well adapted to recreational uses have a fluctuation of water levels due to their use as power storage reservoirs. This reduces their recreational value, but thus far, there has not been found a remedy for this situation. In the 1937 Legislative Session a Water Control Commission was set up for the purpose of studying and coping with this problem.

MAINE--NEW HAMPSHIRE COASTAL BASINS

GENERAL DESCRIPTION

The Maine--New Hampshire Coastal Basin covers the small coastal areas lying between the Androscoggin, Presumpscot, Saco, Piscataqua and Merrimack Rivers. The principal streams in this area are the Royal, Kennebunk and Mousam Rivers in Maine, and the Hampton River in New Hampshire. This basin extends along the coast for about 100 miles, and inland a maximum distance of 25 miles. A total area of about 750 square miles is included in these several small coastal basins.

The area is a coastal lowland, with generally rolling country, except near the shore, where the topography is flat and there are numerous sections of swamp land. The underlying rock is granite, covered with glacial sand and gravel. The coastline is irregular and rocky, with headlands which are typical of the Maine coast. A large percentage of the coastline, especially south of Portland, consists of sandy beaches separated by small rocky headlands and often broken by tidal creeks extending to the tidal marshes inland.

This coastal basin is a moderately important agricultural section, with about 21% of it in cleared crop or pasture land. Most of the remaining area is in cut-over woodland, much of it on farms. Aside from tidal estuaries, there is practically no water area, the total amounting to less than 1%.

The average annual precipitation is about 43 inches, uniformly distributed throughout the year. It is somewhat greater in the northeastern portion than along the New Hampshire coast. The winter temperatures average from 24° to 26°, and the summer temperature averages about 66°, the yearly range being less than that in any other part of Maine except the eastern coastal region.

The Royal River drains the greater part of the coastal area lying between the Androscoggin and Presumpscot Rivers. It is a relatively unimportant river and has but one site which is developed for power.

The Kennebunk River drains the area immediately south of the Saco basin. The basin is about 15 miles long, 4 miles wide, and has an area of 38 square miles. Kennebunk Pond, at the extreme headwaters, and Alewives Pond, about midway along its course, are the only two ponds in the watershed.

The Mousam River, the largest of these coastal streams, rises just east of the headwaters of the Salmon Falls River, and flows southeast, draining an area of nearly 200 square miles. There is some fall in this river and several water power plants are located along its course.

The Hampton River, formed by the confluence of several small streams in the salt marshes back of Hampton Beach, is a tidal arm entering the ocean just south of the Beach.

No discharge records are kept on any of these rivers.

HUMAN OCCUPANCY

Population The total 1930 population of these detached coastal areas was 139,000, of which 95% was in Maine. The region is the most thickly settled of all the Maine river basins, the population density being 186 per square mile. Nevertheless, there are only five cities and towns of over 2500 population, the largest and most important of which is Portland. All five are in Maine:

Portland	70,810
South Portland	13,840
Sanford	13,392
Kennebunk	3,302
York	2,532

These communities contain nearly three-fourths of the total population of the basin; the remainder are in small towns, most of which are on the coast. Portland, the largest city in Maine, is the trade and wholesale center for western Maine, and in some lines of commerce it serves the entire state. Although it has a number of manufacturing establishments, it is essentially a railroad center, a port of entry, and a distribution point. Because of its importance in these respects, Portland reflects the commercial and industrial activity of the entire state. Sanford, located inland on the Mousam and Great Works rivers, is an active manufacturing and trading community.

Of the five cities and towns of more than 2500 population, only one lost in the 1920-1930 decade. Portland has grown in each decade since 1900. It increased only 2% between 1920 and 1930, in contrast to an increase of 18% in the previous decade. South Portland, on the other hand, increased 50% between 1920 and 1930. Most of the smaller towns gained slightly. Trends indicate a moderate growth in the future; the amount of growth will be influenced by activities throughout the state, including to a marked degree those related to the recreational industry.

Agriculture Farms in this basin secure about three-fourths of their revenue from dairy and poultry products. The high unit value of farm land can be attributed to three factors: (1) the ready market (afforded by nearby population centers and summer colonies) for dairy and poultry products; (2) the constant demand for sites for summer homes and estates; (3) the comparatively small acreage of farms as contrasted to that of the average farm elsewhere in Maine and New Hampshire. The first two factors point to a consistent increase in farm land value and tend to confirm the assumption that specialized farming can continue to be successfully carried on in the basin.

Industry The region contains a variety of industries - shoe, textile, lumber, canning and others. Portland is the center of manufacturing activity, and at present manufacturing space, especially in small units, is at a premium in that city. In Portland may be found the largest canning factory in New England. Sanford textile mills are noted for their quick recovery after a severe decline in activity during the early part of the depression. The value of products manufactured in Portland in 1933 was about $16,000,000.

Increased activity among small manufacturing establishments is in evidence in the vicinity of Portland. New enterprises are attracted by the general commercial activities of that city, and by its importance as a transportation center.

Mining A limited amount of granite quarrying has been carried on in many localities, but the amount of production is low and relatively unimportant.

Lumbering Timberlands bearing white and Norway pine and hardwoods are scattered and limited in area. They contain principally young second growth. Lumbering operations are confined to small saw mills. The woodland tracts are more important for recreational purposes than their timber production. The only expansion anticipated in lumbering operations will be that brought about by maturity of young pine stands scattered throughout the region.

Fishing Commercial fishing, carried on on a small scale at some of the ports, is of value principally in connection with the summer trade. The only change anticipated is in the shell fish industry, which is menaced by pollution and by inadequate control of the catch.

Recreation The coast in these basins is a favorite vacation spot attracting visitors in great numbers from this country and Canada. Recreational use has been so intensive that property values along the seashore are based wholly upon that demand, and at some beaches prices now exceed fifteen dollars a front foot and two thousand dollars an acre. Such values illustrate better than can general description the extent of recreational development along the New Hampshire and southwestern Maine coast. The inland section also has a summer population, but smaller than that on the coast.

Transportation The many harbors and tidal estuaries in this basin are used almost entirely by pleasure craft. Commercial navigation is confined primarily to Portland Harbor, one of the best on the Atlantic coast.

The Atlantic coast highway (U. S. Route #1) traverses the basin, and from it numerous supplementary highways lead to all the important cities and towns in the area. The New England Regional Planning Commission has recommended construction of a freeway a few miles inland from Route #1, so as to relieve congestion on the existing coastal highway.

Railroad service is provided by the shore routes of the Boston and Maine and Maine Central railroads. In addition, direct service from Portland to Montreal and other Canadian points is furnished by the Canadian National Railway.

Scheduled air transport service is maintained from the Portland (Stroudwater) airport to Boston and to Augusta and other points in northern and eastern Maine. Landing fields are located at Portland, York, Sanford, Scarboro, and Brunswick, Maine.

WATER USE AND CONTROL

Pollution The greatest permanent resident concentrations are in the vicinity of Portland and Sanford. Portland Harbor receives the untreated domestic wastes of approximately 80,000 people and the industrial wastes from a heterogeneous group of small plants employing about 5000 people. Since the harbor and tidal flats nearly surround the peninsular which the city occupies, an unsightly and unhealthy situation exists. Portland harbor is a part of Casco Bay, on the islands and shores of which there is intensive recreational development. Increase in the polluted harbor conditions tends to reduce property values. Moreover, it will discourage summer visitors from spending their vacations in the vicinity.

Sanford, a large inland industrial center, has a population of over 13,000, a third of which is employed in industry. The industrial wastes, practically all from shoe or textile plants, perhaps cause less serious pollution than the domestic wastes, although no treatment is applied to either before entering the Mousam River.

Downstream on the Mousam, Kennebunk, with 3000 people, increases the river pollution load with both types of waste. This stream carries such a heavy pollution load in proportion to its size that it constitutes a very real menace to public health in the vicinity and retards expansion of the recreational communities near its outlet.

In other parts of the basin there are two types of pollution problems. One is the usual result of intensive occupation by summer residents, namely, contamination of lakes and ponds to such extent that bathing is unpleasant and fish life is destroyed. The solution to this problem depends on the carrying out of local sanitary ordinances.

The second type of problem arises from recreational occupancy of ocean beaches. In the early years circumstances were such that sewerage was a problem for the individual. More recently, organized systems have been established in concentrated areas and through these systems untreated sewage has been discharged into the nearest waterway. The present volumes of waste have created obnoxious local situations which will become intensified as settlements become more dense. The greatest handicap is of an engineering and financial nature because the installation of intercepting mains is made so difficult by low elevations and ledges. Improvement in methods of discharge of domestic waste is needed at Scarboro, Old Orchard Beach, Kennebunk and Wells.

Old Orchard Beach has the largest concentration of summer people and hence presents the most serious problem. Here the year-round population is 1700, but the hotels have a capacity of 5000, and at times the overnight population probably exceeds 30,000.

Water Supply Most of the communities in this area have public water supplies, the sources of which are divided about equally among lakes, streams and wells. The largest water supply in Maine is taken from Sebago Lake, in the Presumpscot basin, by the Portland Water District and distributed to Portland, Falmouth, Gorham, Windham, Westbrook, South Portland and other smaller communities.

Although present supplies are adequate, opportunities exist along the coast to develop additional ground and surface sources, when and if they are needed. As ground water sources along coastal sections are subject to salt water infiltration if drawn down excessively, such sources are generally suitable only for small supplies.

There are several towns in the area without public water supplies. If public health, fire protection, and general convenience were taken into account, installation of systems in some of these towns would be economically justified.

Flood Control Damages from floods on these streams are negligible. The land which is occasionally submerged is mostly pasture or woodland, and no large communities are located along the rivers. No general application of flood prevention measures is warranted.

Power The Mousam River is the only stream in this area which has a fall of any significance. The total power on the river is 4749 horsepower, developed at 8 plants, 6 of which have installation of less than 500 horsepower. The largest development is at Old Falls, where the plant of the York Utilities Company has an installed capacity of 2250 horsepower. The same company has another plant, called New Dam, where 1000 horsepower are developed.

There is an installation at Yarmouth, on the Royal River, where the wheel capacity is 219 horsepower.

The Kennebunk River has practically no power possibilities. The fall of the river is rather steep, averaging 15.4 feet per mile, but the discharge of the river is too meagre to permit other than extremely small power developments. House Document #481, 71st Congress, 2nd Session, lists three saw mills on the river with a total rated horsepower of 90. New power could be developed at some points on the river, but this power would be so small that it would not be economically feasible.

On a tidal arm near the mouth of the Kennebunk River there is a tidal grist mill which is still in operation - one of the few in the country.

Navigation Natural harbors and anchorages are numerous along the coast, and are used by large numbers of fishing and pleasure craft. Portland Harbor has the greatest amount of commercial shipping, 2,786,363 tons in 1935. The chief commodity of freight entering the harbor is coal. During the winter season cargoes, principally grain, are shipped from Montreal and other Canadian points to Portland by rail, and thence by boat out of Portland Harbor because it is open the year round, while the St. Lawrence is frozen over nearly half the year. The project depth in Portland harbor is 35 feet in the lower harbor and 30 feet in the main channel and anchorage basin. There is a 12-foot channel in Back Cove. The removal of two ledges in the main ship channel is the navigation improvement most needed.

Various New Hampshire agencies have investigated the possibilities of, and recommended development of Rye Harbor as a yachting center. Contingent on receiving supplementary federal funds, the state has made available $154,000 for constructing jetties and dredging the harbor. There has also been discussion of and support for development of an inland waterway from Hampton River south to Newburyport Harbor, possibly to Cape Ann.

Erosion There are several localities which have evidence of slight erosion accompanied by occasional gullying. Moderate sheet erosion occurs infrequently, and only two small localities, near Scarboro and Brunswick, experience any notable degree of wind erosion.

"The Desert of Maine," between Freeport and Brunswick, is a rapidly increasing expanse of shifting sand in an area which was actively farmed a few decades ago. The exact cause of this phenomenon has not thus far been ascertained.

Drainage Along most of this coastal area there is a continuous frontage of good beach backed by salt marsh. The beach is occupied by summer homes, hotels and seasonal business establishments. Naturally the large number of mosquitoes bred in the nearby marshes annoy the summer people, and serious consideration has been given to practical methods of control. Marsh drainage would abate the mosquito nuisance and eliminate the costs of applying oil. However, because there is no evidence of malaria mosquitoes it is pertinent to consider the inevitable disruption of biological life that would result from complete drainage. A conservative procedure would be to restrict immediate drainage to the marsh land adjoining the large settlements. On the basis of inaugurating a drainage control program limited, temporarily, at least, to the recognized recreational centers of this basin, 4640 acres of marsh have been designated by the Maine State Entomologist in the following municipalities: Cape Elizabeth, 150 acres; Scarboro, 2000 acres; Old Orchard Beach, 540 acres; Kennebunkport, 550 acres; and Wells, 1400 acres.

Recreation Recreation seekers supply a large part of the income realized in this section. Hence the primary water problems are those which concern the preservation or improvement of recreational attractions. It is advisable that any water proposals be thoroughly investigated by qualified recreation and wildlife authorities.

TABLE III-A

SUMMARY OF STREAM FLOW RECORDS - MAINE BASINS

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
St. John River Basin						
St. John River at Van Buren, Me.	8270	20(a)	133,000	720	14,100	134,000
St. John River below Fish River at Ft. Kent, Me.	5690	10	117,000	940	9,900	121,000
Allagash River near Allagash, Me.	1250	5	23,400	131	2,075	23,400
Fish River near Ft. Kent, Me.	867	7	10,300	47	1,344	11,000
Aroostook River at Washburn, Me.	1620	6	37,000	94	2,570	37,900
St. Croix River Basin						
St. Croix River at Vanceboro, Me.	435	8	3,650	21	692	4,010
St. Croix River near Baileyville, Me.	1320	16	22,900	500	2,060	23,300
Grand Lake Stream at Grand Lake Stream, Me.	249	8	1,510	11	327	1,520
Machias River Basin						
Machias R. at Whitneyville, Me.	465	22	11,100	10	999	11,100
East Machias R. near East Machias, Me.	234	9	3,010	23	482	3,010
Union River Basin						
West Branch of Union R. Amherst, Me.	139	17	3,450	7	272	3,620
Penobscot River Basin						
West Branch of Penobscot R. at Millinocket, Me.	1910	35	--	--	3,066	--
West Branch of Penobscot R. near Medway, Me.	2120	20	23,700	100	3,684	24,100

(a) Discontinued in 1928

SUMMARY OF STREAM FLOW RECORDS - MAINE BASINS

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second: Max. Day	Min. Day	Mean Annual	Peak Flow
Penobscot R. Basin (cont.)						
Penobscot R. at West Enfield, Me.	6600	29	152,000	1470	11,680	153,000
East Branch of Penobscot R. at Grindstone, Me.	1070	28	33,700	30	1,866	35,100
Mattawamkeag River at Mattawamkeag, Me.	1500	29	42,800	86	2,749	43,900
Piscataquis River near Foxcroft, Me.	286	32	18,100	5	656	21,700
Piscataquis River at Medford, Me.	1170	12	46,400	127	2,257	50,200
Sebec River at Sebec, Me.	344	12	10,000	2	595	11,400
Pleasant River near Milo, Me.	322	16	22,200	22	689	24,400
Passadumkeag River at Lowell, Me.	301	11	5,680	4	494	5,680
Kennebec River Basin						
Moosehead Lake at "East Outlet", Me.	1240	40	Lake Levels, only, on record			
Kennebec River at Moosehead, Me.	1240	17	13,400	62	1,813	13,600
Kennebec River at The Forks, Me.	1570	31	18,000	215	2,516	23,700
Kennebec River at Bingham, Me.	2710	8	51,600	318	3,850	55,200
Kennebec River at Waterville, Me.	4270	44	151,000	100	7,081	--
Dead River at The Forks, Me.	878	32	27,600	20	1,381	28,700
Austin Stream at Bingham, Me.	92	5	4,160	4.4	176	5,820
Carrabasset River near No.Anson, Me.	351	16	20,100	18	678	24,100

SUMMARY OF STREAM FLOW RECORDS - MAINE BASINS

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
Kennebec R. Basin (cont.)						
Sandy River near Mercer, Me.	534	8	25,500	35	918	33,000
Sebasticook River near Pittsfield, Me.	593	8	14,300	14	938	14,400
Cobbossecontee Stream at Gardiner, Me.	220	46	4,320	13	318	5,020
Androscoggin River Basin						
Androscoggin R. at Errol Dam, N.H.	1095	15(b)	12,500	32	1,785	12,500
Androscoggin R. at Gorham, N.H.	1390	7	19,500	958	2,430	19,900
Androscoggin R. at Rumford, Me.	2090	44	68,300	--	3,476	74,000
Androscoggin R. at Auburn, Me.	3257	8	114,000	465	5,670	135,000
Magalloway R. at Aziscohos Dam, Me.	233	23	4,660	0	492	--
Swift R. near Roxbury, Me.	95	6	--	5.4	206	13,000
Little Androscoggin near So.Paris, Me.	76	16	5,740	1	139	6,980
Presumpscot River Basin						
Presumpscot R. At Out let of Sebago Lake, Me.	436	49	--	0	640	--
Saco River Basin						
Saco R. near Conway, N.H.	386	7	33,900	40	865	40,600
Saco R. at Cornish, Me.	1300	20	49,700	90	2,584	51,300
Saco R. at W.Buxton, Me.	1572	30	27,800	121	2,949	58,200
Ossipee R. at Cornish, Me.	455	20	16,300	28	843	17,200
Piscataqua River Basin						
Salmon Falls R. near Lebanon, Me.	147	8	5,180	6	206	5,490

TABLE IV

EXPLANATORY NOTES
Concerning the table of
SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

Column 1. Town or City. Municipalities, arranged alphabetically, where available information positively indicated the existence of an organized sewerage system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 Census.

Column 3. Population Served. Best available estimate of the persons served by an organized system.

Column 4. Discharge in thousand gallons per day. The best available estimate of the volume of sewage discharged.

Column 5. Treatment. Abbreviations, noted below, indicate the type of treatment applied to the domestic wastes.

Column 6. Chief sources of Industrial Wastes. The industries which commonly pollute streams are indicated by concise reference to the type of plant, product or raw material.

Symbols

---	No information available
(P)	Partial
(s)	Summer resort.
(S)	State Institution
(U)	College or University
Various	Several industries present with none clearly predominant.
Milk	Refers to pasteurizing, ice cream and dairy plants.
Fert.	Fertilizer factory.
Oil	Petroleum products; storage or distribution plants.
Gas	Illuminating gas manufacturing plant.
Cannery	Includes fish packing.

Im.	Imhoff Tank	A.	Aeration.
Sp.	Septic Tank	Cl.	Chlorination
SF.	Sand filtration.	St.	Settling
F.	Filtration.	Sc.	Screening (fine)
CP.	Cesspool	Br.	Barging sludge to sea.
Sl.	Sludge treatment.	Sm.	Sedimentation
AcSl.	Activated sludge plant.	Ir.	Irrigation

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments

TABLE IV-A

SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

ST. JOHN BASIN

Town or City	Domestic Sewage: Population 1930	Population Served	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Blaine, Maine	1061	200	--	none	--
Caribou	7248	4000	--	none	Fertilizer
Fort Fairfield	5393	2500	--	none	Starch
Fort Kent	4726	2000	--	none	Starch
Houlton	6865	5000	600	none	Fertilizer
Limestone	1953	800	--	none	Starch
Madawaska	3533	2000	--	none	Paper
Mars Hill	1837	1000	--	none	Starch
Presque Isle	6965	4700	--	Im.Sl.	Starch and Fertilizer
Van Buren	4721	2500	--	none	Starch
Washburn	1974	800	--	Sp.	--

ST. CROIX BASIN

Baileyville, Maine	2017	1200	--	none	Paper
Calais	5470	4000	--	none	--

EASTERN MAINE COASTAL BASINS

Bar Harbor, Maine	4486	4000	--	none	--
Castine	726	1300	--	none	--
Eastport	3466	3500	30	none	Cannery
Ellsworth	3557	2000	--	none	Milk
Lubec	2994	1000	--	none	Cannery
Machias	1856	600	10	none	--
Milbridge	1213	300	--	none	Cannery
Stonington	1418	200	--	none	Cannery

PENOBSCOT BASIN

Bangor, Maine	28749	23000	4000	none	Various
Brewer	6329	5000	--	none	Pulp and Paper
Brownville	1910	500	--	none	--
Bucksport	2135	500	--	none	Paper
Dover-Foxcroft	3750	2000	--	none	Woolens
Danforth	1467	500	--	none	Milk
East Millinocket	1593	1600	275	none	Paper
Guilford	1735	500	--	none	Woolens
Lincoln	2970	1500	--	none	Paper and Woolens
Milford	1203	510	--	none	--
Millinocket	5830	5800	--	none	Paper
Milo	2912	3000	15	none	--
Old Town	7266	4500	--	none	Paper and Woolens
Orono	3338	4000	--	none	Paper

PENOBSCOT BASIN (cont'd)

Town or City	Domestic Sewage: Population 1930	Population Served	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Sangerville, Maine	1225	300	--	none	Woolens
Veazie	568	200	--	none	--
Winterport	1437	700	--	none	--
CENTRAL MAINE COASTAL BASIN					
Belfast, Maine	4993	3000	--	none	Fertilizer
Boothbay Harbor	2076	2000	--	none	Cannery
Camden	3606	3000	--	none	Woolens
Rockland	9075	8000	320	none	Milk and Gas
St. George	2108	300	--	none	--
Searsport	1414	800	--	none	Fertilizer
Thomaston	2214	1500	--	none	Cannery
Waldoboro	2311	1200	--	none	Cannery
Wiscasset	1186	600	--	none	--
PRESUMPSCOT BASIN					
Bridgton, Maine	2659	2000	--	none	Woolens
Gorham	3035	100	.2	none	--
Westbrook	10807	6000	--	none	Paper and Cotton
KENNEBEC BASIN					
Augusta, Maine	17198	12000	--	none	Cotton and Paper
Bath	9110	7000	--	none	Milk
Benton	1156	175	--	none	--
Bingham	1592	500	--	none	--
Dexter	4063	2000	--	none	Woolens
Fairfield	5132	2000	--	none	Woolens and Pulp
Farmingdale	1044	700	--	none	--
Farmington	3600	1800	--	none	Milk
Gardiner	5609	5000	50	none	Paper
Hallowell	2675	2000	--	none	--
Jackman	1099	500	--	none	--
Kingfield	1024	800	--	none	--
Madison	3956	3000	--	none	Paper and Woolens
Newport	1731	1000	--	none	Woolens and Milk
Oakland	2664	1500	--	none	Woolens and Milk
Pittsfield	2935	2000	375	Sp.	Woolens
Randolph	1377	1250	2	none	--
Richmond	1964	1000	--	none	Woolens
Skowhegan	6433	4000	--	none	Woolens and Milk
Waterville	15454	10000	--	none	Woolens and Cotton
Wilton	3266	1500	--	none	Woolens
Winslow	3917	2500	--	none	Paper

ANDROSCOGGIN BASIN

Town or City	Domestic Sewage: Population 1930	Population Served	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Berlin, New Hampshire	20018	15000	1500	none	--
Gorham	2763	--	--	none	--
Auburn, Maine	18571	15000	--	none	Milk
Bethel	2025	1000	--	none	--
Brunswick	7604	7000	--	none	Cotton and Milk
Canton	767	500	--	none	Tannery
Dixfield	1521	1000	--	none	--
Jay	3106	200	--	none	Paper
Lewiston	34948	30000	--	none	Cotton and Woolen
Livermore Falls	3148	2500	--	none	Paper
Mechanic Falls	2033	--	--	none	Paper
Mexico	4767	2000	--	none	Milk
Norway	3145	2500	300	none	--
Paris	3761	2500	--	none	--
Rumford	10340	7000	--	none	Paper
Topsham	2111	1200	--	none	Paper

SACO BASIN

Bartlett, New Hampshire	1119	300	30	none	--
Ossipee	1230	100	1	Sp.F.	--
Biddeford, Maine	17633	15000	--	none	Cotton
Limerick	1199	600	10	none	Woolen and Rayon
Parsonsfield (Kezar F.)	897	500	--	none	Woolens
Saco	7233	4000	--	none	Cotton

PISCATAQUA BASIN

Dover, New Hampshire	13573	10000	570	none	--
Durham	1217	2000(U)	200	Im.	--
Exeter	4872	4000	224	Sp.	--
Farmington	2698	1000	48	Sp.F.	--
Newmarket	2511	2500	182½	SF.	--
Portsmouth	14495	12000	1200	SF.	--
Rochester	10209	8000	2600	SF.	--
Somersworth	5680	3000	189	SF.	--
Kittery, Maine	4400	4000	--	none	--

MAINE-NEW HAMPSHIRE COASTAL BASIN

Cape Elizabeth, Maine	2376	1900	--	none	--
Falmouth	2041	1500	--	none	--
Freeport	2184	500	--	Sp.	--
Kennebunk	3302	1000	--	none	--
Kennebunkport	1284	1000	--	none	--
Old Orchard Beach	1620	1500	--	CP.	Milk
Portland	70810	60000	10500	none	Various

MAINE-NEW HAMPSHIRE COASTAL BASIN (cont'd)

Town or City	Domestic Sewage: Population 1930	Population Served	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Sanford, Maine	13392	10000	—	none	Woolens
South Portland	13840	14000	—	none	Milk
Wells	2047	500	—	Sp.	—
Yarmouth	2125	1700	7½	none	Cotton
York	2532	300	—	Sp.	—
Hampton, New Hampshire	1507	—	—	Im.	—

EXPLANATORY NOTES
concerning tables of the
ORGANIZED WATER SUPPLY SYSTEMS

Column 1. Town or city. Municipalities, arranged alphabetically, where available information indicates the existence of an organized public or semi-public water supply system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 census.

Column 3. Population Served. Best available estimate of the persons served by an organized system (as for the year 1936).

Column 4. Consumption in thousand gallons per day. Best available estimate of the normal daily requirement.

Column 5. Sources of supply. The type of source drawn from is indicated by symbols:- R. for Reservoir, Pond or Lake; W. for Wells, either deep or shallow; Spr. for Spring; Str. for Streams.

Column 6. Watershed area in square miles. Best available estimate of the drainage area upon which the water supply is dependent.

Column 7. Capacity in millions of gallons. Best available estimate of the quantity of water stored by, or immediately available to, the municipal supply.

Column 8. Type of Treatment. Available information concerning the methods used to improve the quality of the water served.

SYMBOLS

(2), etc. Numerals enclosed in parentheses indicate the number of separate water supply systems which serve the municipality. Where there is only one system no symbol is necessary.

(S) Includes State institution
(T) Includes Summer population served
(U) Includes College or School
(s) Provides Summer service only
(a), (b), etc. Letters enclosed in parentheses link civil divisions served by the same water source:-
In column 3 and 4 they link municipalities where available information does not give the number served in each town.
In column 5 letter indicates that the civil division imports water.
In column 6 and 7 letter indicates that the civil division exports water.
Letters link municipalities within one state and basin; cross-references between basins or states appear in footnotes.

Symbols (continued)

A.	Aeration	K.	Activated carbon
Al.	Alum	L.	Lime
AlSl.	Aluminum sulphate	MF.	Mechanical filter
Am.	Ammonia	PF.	Pressure filter
AmSl.	Ammonium sulphate	pH.	Correction of reaction
AS.	Alum - Soda Ash	RF.	Rapid filter
CC.	Corrosive correction	S.	Soda Ash
Cl.	Chlorine	SF.	Slow filter
Co.	Coagulation	Sm.	Sedimentation
CuSl.	Copper sulphite	SoCl.	Sodium hypochlorite
F.	Filter	St.	Storage of protective significance.
IR.	Iron removal		

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments
Annual Reports, Public Utilities Commissions

Table V-A

ORGANIZED WATER SUPPLY SYSTEMS

ST. JOHN BASIN

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Blaine, Maine	1,061	375	26	(a)	--	--	none
Caribou	7,248	3,161	400	Str.	--	--	Cl.
Fort Fairfield	5,393	1,309	--	Spr.& Str.	--	--	--
Fort Kent (2)	4,726	1,099	--	Spr.& Str.	--	--	--
Houlton	6,865	5,422	800	Spr.& Str.	--	--	Cl.
Limestone	1,953	675	--	Str.	--	--	--
Madawaska	3,533	874	85	Str.	--	--	Cl.
Mars Hill	1,837	652	45	(a)	--	--	none
Presque Isle	6,965	2,610	400	R.	--	--	Cl.
Van Buren	4,721	2,145	--	Str.	--	--	--
Washburn	1,974	450	--	W.	--	--	--
Westfield	776	98	--	R.	(a)	(a)	--

ST. CROIX BASIN

Baileyville, Maine	2,017	1,316	250	Str.	--	--	PF.& Cl.
Calais	5,470	5,160	514	W.	--	--	--

EASTERN MAINE COASTAL BASIN

Bar Harbor, Maine	4,486	5,959(T)	--	R.	--	--	--
Brooklin (s)	782	90	--	--	--	--	--
Castine (2)	726	1,061(T)	102	W. & R.	--	--	F.
Cherryfield	1,112	94	3½	Spr.	--	--	--
Columbia Falls	583	112	--	Spr.	--	--	--
Dedham (s)	279	259	--	--	--	--	--
Eastport	3,466	3,518(a)	200(a)	(a)	--	--	Cl.

EASTERN MAINE COASTAL BASIN (Continued)

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil.gal.	Type of treatment
Ellsworth, Maine	3,557	4,575(T)	--	R.	--	--	Cl.
Hancock (s)	760	124	4½	W.	--	--	--
Harrington	865	518	--	Spr.	--	--	--
Lamoine (2)	354	270	--	R. & Spr.	--	--	--
Lubec	2,994	1,789	--	W.	--	--	--
Machias	1,856	1,256	150	Str.	--	--	Cl.
Millbridge	1,213	660	--	Spr.	--	--	--
Mt. Desert (3)	2,022	2,749(T)	450	R.	--	--	--
Perry	992	(a)	(a)	R.	(a)	(a)	Cl.
Sorrento	143	248	--	R.	--	--	--
Southwest Harbor	888	814	--	R.	--	--	--
Stonington	1,418	476	70	R.	--	--	--
Sullivan (s)	873	109	--	R.	--	--	--
Surry (s)	488	56	--	Spr.	--	--	--
Tremont (s)	954	79	--	R.	--	--	--
Winter Harbor	517	382	--	R.	--	--	--
PENOBSCOT RIVER BASIN							
Bangor, Maine	28,749	30,735	3,935	Str.	--	12	MF.&Cl.
Brewer	6,329	4,500	--	R.	--	--	Cl.
Brownville (2)	1,910	1,189	10	Spr. & W.	--	--	Cl.
Bucksport	2,135	1,485	100	R.	--	18	RF.
Danforth	1,467	435	70	W.	--	--	Cl.
Dover-Foxcroft (2)	3,750	3,120	500	R.	--	--	Cl.&Am.
East Millinocket	1,593	1,050	240	Str.	--	--	Cl.
Guilford	1,735	1,691	--	R.	--	--	--
Howland	1,605	656	--	--	--	--	--
Island Falls	1,455	675	3½	Str.	--	--	--
Lincoln	2,970	1,290	--	R.	--	--	Cl.
Milford	1,203	1,091	(a)	(a)	--	--	RF.&Cl.
Millinocket	5,830	3,675	850	Str.	--	--	F. &Cl.
Milo	2,912	1,954	--	Str.	--	--	Cl.
Monson	1,121	506	--	W.&Spr.	--	--	--

PENOBSCOT RIVER BASIN (Continued)

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Old Town, Maine	7,266	6,581	642(a)	Str.	(a)	(a)	RF.& Cl.
Orono	3,338	2,374	--	R.	--	--	Cl.
Patten	1,278	236	--	Spr.	--	--	--
Sangerville	1,225	690	--	--	--	--	--
Stockton Springs	877	728	50	R.	--	--	--
Veazie	568	405	--	R.	--	--	Cl.
Winterport	1,437	1,061	47	Str.	--	--	Cl.

CENTRAL MAINE COASTAL BASIN

Belfast, Maine	4,993	3,960	--	Str.	--	--	F.AmSul. Cl.
Boothbay	1,345	(a) (T)	(a)	R.	(a)	(a)	Cl.
Boothbay Harbor	2,076	4,736(a)(T)	400(a)	(a)	--	--	Cl.
Brooks	729	274	8	Spr. & W.	--	--	--
Camden	3,606	3,592	(b)	(b)	--	--	Cl.
Damariscotta	825	904(T)	--	R.	--	--	--
Friendship	742	368	--	Spr.	--	--	--
Jefferson	888	49	--	Spr.	--	--	--
Monhegan(s)	109	338	--	W.	--	--	--
Morrill	288	79	1	W.	--	--	--
Newcastle	914	428	--	R.	--	--	--
Northport (s)	413	750(T)	--	Spr. & W.	--	--	--
North Haven	476	731(T)	100	R.	--	--	none
Owl's Head	574	570	(b)	(b)	--	--	Cl.
Rockland	9,075	9,038	2,000(b)	R.	(b)	(b)	Cl.
Rockport	1,651	1,642	(b)	(b)	--	--	Cl.
St. George	2,108	278	--	W.	--	--	--
Searsport	1,414	1,192	--	R.	--	--	--
Southport	412	1,031(T)	60	R.	--	--	--
Thomaston	2,214	2,205	(b)	(b)	--	--	Cl.
Union	1,060	255	--	Spr. & W.	--	--	--
Vinalhaven	1,843	1,219	60	R.	--	--	none
Waldoboro	2,311	630	80	W.	--	--	--

CENTRAL MAINE COASTAL BASIN (Continued)

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Warren, Maine (2)	1,429	802	30(b)	W. R. & (b)	--	--	Cl.
Wiscasset	1,186	720	--	Spr. & Str.	--	--	--

KENNEBEC RIVER BASIN

Anson, Maine	2,238	1,568	--	R.	--	--	Cl.
Augusta	17,198	11,595	1,897	R.	2½	--	Cl. & L.
Bath	9,110	10,238	1,318	Str. & R.	21(c)	(c)	Cl.
Belgrade (s)	978	120	--	R.	--	--	--
Benton	1,156	566	--	--	--	--	--
Bingham (2)	1,592	1,241	--	R.	--	--	Cl.
China	1,163	71	--	Spr.	--	--	--
Dexter	4,063	2,434	226	R.	--	--	Cl.
Eustis	601	386	--	Spr.	--	--	--
Fairfield	5,132	2,614	(a)	(a)	--	--	Cl.
Farmingdale	1,044	915	(b)	(b)	--	--	SF. & Cl.
Farmington (2)	3,600	3,469	--	R, W, & Spr.	--	--	--
Flagstaff	179	68	5	Spr.	--	--	--
Gardiner	5,609	4,920	940(b)	Str. & R.	(b)	(b)	SF. & Cl.
Greenville (2)	1,615	1,080	28	R. & W.	--	--	none
Hallowell	2,675	2,040	252	R.	--	--	Cl.
Hartland	1,155	874	--	R.	--	--	--
Jackman	1,099	735	--	Spr. & R.	--	--	--
Kingfield,	1,024	840	--	Str.	--	--	Cl.
Madison	3,956	2,569	250	R.	--	--	Cl.
Newport	1,731	1,744	--	R.	--	--	Cl.
New Portland	818	195	--	Spr.	--	--	--
New Sharon	750	128	--	W. & Spr.	--	--	--
Norridgewock	1,481	94	--	Spr.	--	--	--
Oakland	2,664	1,774	480	R.	--	--	Cl.
Phillips	1,143	776	50	R.	--	--	Cl.

KENNEBEC RIVER BASIN (Continued)

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Pittsfield, Maine	2,935	2,179	--	W. & Spr.	--	--	--
Randolph	1,377	1,207	(b)	(b)	--	--	--
Richmond	1,964	1,590	--	Str.	--	--	PF. & Cl.
Skowhegan (5)	6,433	5,344	250	Spr.	--	--	Cl.
Strong	878	488	.2	R.	--	--	--
Vassalboro	1,815	131	--	Str.	--	--	--
Waterville	15,454	7,579	2,812(a)	R.	(a)	(a)	Cl.
Wilton	3,266	1,732	--	R.	--	--	--
Winslow	3,917	1,920	(a)	(a)	--	--	Cl.
Winthrop	2,234	1,743	100	R.	--	--	Cl.
Woolwich	671	754	(c)	(c)	--	--	Cl.

ANDROSCOGGIN RIVER BASIN

Andover, Maine	788	495	--	Str.	--	--	--
Auburn	18,571	19,339	3,000	R.	17.89(a)	(a)	Cl.
Bethel (2)	2,025	1,069	--	Spr. & Str.	--	--	--
Brunswick	7,604	6,375	562	W.	(b)	(b)	Cl. & Am.
Buckfield	972	502	--	R.	--	--	--
Canton	767	262	37	R.	--	--	--
Dixfield	1,521	836	--	R. & Str.	--	--	--
Hebron	791	120	--	R.	--	--	--
Jay	3,106	375	--	(c)	--	--	Cl.
Lewiston	34,948	16,879	6,000	(a)	--	--	Cl.
Lisbon	4,002	4,001	180	W.	--	--	None
Livermore Falls	3,148	2,426	--	R.	(c)	(c)	Cl.
Mechanic Falls	2,033	1,538	100	R. & Str.	--	--	F. Sm.& Cl.
Mexico	4,767	1,680	--	Str. & Spr.	--	--	--
Norway	3,145	2,921	300	R.	--	--	Cl.
Paris (5)	3,761	2,674	--	Spr. & W.	--	--	--
Rangeley	1,472	934	--	Str.	--	--	Cl.
Rumford (2)	10,340	3,101	500	Str. & Spr.	--	--	Cl.
Topsham	2,111	1,770	(b)	(b)	--	--	Cl. & Am.

ANDROSCOGGIN RIVER BASIN (Continued)

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Berlin, N. H.	20,018	18,500	1,750	Str.	--	22	Cl.
Errol	293	300	10	Spr. & R.	--	.19	--
Gorham	2,763	370	250	Str.	--	--	--
Randolph	82	175	14	Spr. & Str.	--	.11	--
Wentworth's	38	--	--	--	--	--	--

PRESUMPSCOT RIVER BASIN

Bridgton, Maine(2)	2,659	2,119	41	Spr. & R.	--	--	Cl.
Cumberland	1,378	202	--	Spr. & W.	(b)	(b)	--
Falmouth	2,041	1,665	(a)	(a)	--	--	Cl.
Gray	1,189	311	15	Spr.	--	--	--
Gorham	3,035	2,475	(a)	(a)	--	--	Cl.
Harrison	966	158	--	--	--	--	--
Standish (2)	1,317	206	4	Spr.	--	--	Cl.
Westbrook	10,807	8,809	(a)	(a)	--	--	Cl.
Windham	2,076	1,691	(a)	(a)	--	--	Cl.
Portland		Exported Me. - N. H. Coastal Basins		R.	436(c)	400(c)	Cl.

(a) See Portland, Me.-N.H. Coastal Basins.
(b) Serves North Yarmouth, Me.-N.H. Coastal Basins.
(c) Serves Portland, South Portland and Scarborough in Me.-N.H. Coastal Basins.

SACO RIVER BASIN

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Bartlett, N.H.(3)	1,119	590	80	Str. R.& Spr.	--	12	--
Conway (2)	3,217	--	--	Str.	--	--	--
Freedom	390	--	--	Str.	--	--	--
Jackson	321	100	--	Str.	--	--	--
Madison	535	55	5	Spr.	--	.01	--
Ossipee	1,230	950	35	R.	--	.2	--
Tamworth	955	--	--	Spr.	--	--	--
Biddeford, Me.(2)	17,633	20,370(T)	2,000(a)	Str.	(a)	(a)	AlSl.F.Cl.
Brownfield (2)	689	60	--	--	--	--	--
Cornish	753	608	8½	Spr.	--	--	--
Fryeburg	1,592	1,245	--	--	--	--	--
Limerick	1,199	461	20	W. & Spr.	--	--	Cl.
Parsonsfield (Kezar F)	897	908	65	W.	--	--	--
Saco	7,233	8,355 (T)	(a)	(a)	--	--	AlSl.F.Cl.

(a) Serves Old Orchard Beach, Me.-N.H. Coastal Basins

PISCATAQUA RIVER BASIN

Berwick, Maine	1,961	1,226	--	Spr.	--	--	F. & Cl.
Eliot	1,462	1,429	150	R.	--	--	Cl.
Kittery	4,400	4,298	450	R.	--	--	Cl.
North Berwick	1,540	998	--	Str.	--	--	--
South Berwick(2)	2,650	1,534	105	R. & Spr.	--	--	Cl.
Candia, N.H.(2)	312	--	--	W.	--	--	--
Dover	13,573	13,000	750	Spr. & W.	--	3	Cl.A.SF.
Durham	1,217	2,500(T)	90	W.	--	.06	Cl.MF.
Epping	1,672	500	50	W.	--	.05	--
Exeter	4,872	5,000	279	W. & R.	--	61.7	Cl. MF.
Farmington	2,698	1,800	86	W.	--	.76	Cl.
Milton	1,206	--	--	W.	--	--	--
Newcastle	378	--	--	W.	--	--	Cl.

PISCATAQUA RIVER BASIN (Continued)

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Newmarket, N. H.	2,511	1,500	110	Str. & W.	--	.21	MF.
Portsmouth	14,495	13,000	1,000	W.	--	.5	Cl.
Raymond	1,165	1,200	60	W.	--	.12	--
Rochester	10,209	10,200	1,000	R.	--	.35	--
Rollinsford	1,409	750	75	W.	--	.08	--
Somersworth	5,680	5,200	329	Str.	--	.9	SF. Cl.

MAINE-NEW HAMPSHIRE COASTAL BASIN

Alfred, Maine	883	480	--	R.	--	--	CuSl.SoCl.
Cape Elizabeth	2,376	1,935	(a)	(a)	--	--	Cl.
Freeport (3)	2,184	1,432	70	Str.	--	--	Cl. F.
Kennebunk	3,302	7,226 (T)	2,000(b)	Str.	(b)	(b)	Cl. F.
Kennebunkport	1,284	2,809 (T)	(b)	(b)	--	--	Cl. F.
North Yarmouth	569	86	(c)	(c)	--	--	--
Old Orchard Beach	1,620	1,871 (T)	(d)	(d)	--	--	AlSl.F.Cl.
Phippsburg	801	175	14	R.	--	--	--
Portland	70,810	57,712	13,263(d)	(a)	--	--	Cl.
Sanford	13,392	13,245	600	W. & R.	--	--	A.SF.Cl.Am.
Scarborough	2,445	1,991	(a)	(a)	--	--	Cl.
South Portland	13,840	11,280	(a)	(a)	--	--	Cl.
Wells	2,047	4,481 (T)	(b)	(b)	--	--	Cl. F.
Yarmouth	2,125	2,955	115	Spr.	--	--	Cl.
York	2,532	3,881	--	R.	--	--	--
Hampton, N. H.	1,507	1,500	150	W.	--	.5	--

(a) Cape Elizabeth, Portland, Scarborough and South Portland in the Me.-N.H. basin and Falmouth, Gorham, Westbrook and Windham in the Presumpscot basin are served by the Portland system from Sebago Lake in the latter basin.
(c) Cumberland, Presumpscot Basin.
(d) Biddeford, Saco Basin.

TABLE VI-A

EXISTING WATER POWER - MAINE BASINS

RIVER	NO. OF PLANTS IN Maine	CAPACITY OF PLANTS OF over 10,000 HP.	1,000 to 9,990 HP.	under 1,000 HP.	CAPACITY USED FOR Utility	Mfg.	TOTAL CAPACITY Horse-power
ST. JOHN *	2	0	1,040	250	1,040	250	1,290
ST. CROIX *	3	0	26,150	610	610	26,150	26,760
EASTERN MAINE COASTALS	14	11,220	1,700	2,794	13,962	1,752	15,714
Orange	3	0	0	545	210	335	545
Machias	3	0	0	902	410	492	902
Others	8	11,220	1,700	1,347	13,342	925	14,267
PENOBSCOT	31	61,400	69,385	5,013	37,264	38,534	135,798
Main Stream	9	0	40,809	300	25,481	15,628	41,109
West Branch	4	61,400	14,888	0	5,000	71,288	76,288
Piscataquis	11	0	4,338	3,283	5,883	1,738	7,621
Others	7	0	9,350	1,430	900	9,880	10,780
CENTRAL MAINE COASTALS	15	0	0	3,637	1,650	1,987	3,637
Megunticook	3	0	0	674	0	674	674
Others	12	0	0	2,963	1,650	1,313	2,963
KENNEBEC	49	109,940	44,510	6,350	107,864	52,936	160,800
Main Stream	13	109,940	28,625	1,181	92,867	46,879	139,746
Sebasticook	15	0	3,435	2,363	3,435	2,363	5,798
Messalonskee	4	0	10,150	0	10,150	0	10,150
Cobbossecontee	6	0	2,300	898	140	3,058	3,198
Others	11	0	0	1,908	1,272	636	1,908

RIVER	NO. OF PLANTS IN		CAPACITY OF PLANTS OF			CAPACITY USED FOR		TOTAL CAPACITY
	N.H.	Me.	over 10,000 HP.	1,000 to 9,990 HP.	under 1,000 HP.	Utility	Mfg.	Horse-power
ANDROSCOGGIN	10	31	157,160	83,220	6,089	50,330	196,089	246,469
Main Stream	10	17	157,160	81,313	1,400	47,782	192,091	239,873
Little Androscoggin	0	7	0	1,907	2,911	2,008	2,810	4,818
Sabattus	0	3	0	0	868	0	868	868
Others	0	4	0	0	910	590	320	910
PRESUMPSCOT	0	14	0	21,965	1,232	4,870	18,327	23,197
Main Stream	0	9	0	21,965	0	4,350	17,615	21,965
Stevens Brook	0	3	0	0	983	520	463	983
Others	0	2	0	0	249	0	249	249
SACO	1	18	25,560	10,336	3,395	35,896	3,395	39,291
Main Stream	0	10	25,560	10,336	1,150	34,521	2,525	37,046
Others	1	8	0	0	2,245	1,375	870	2,245
PISCATAQUA	19	4	0	13,570	5,565	8,860	10,275	19,135
Main Stream	0	0	0	0	0	0	0	0
Salmon Falls	10	1	0	12,170	2,090	7,930	6,330	14,260
Great Works	0	3	0	0	1,235	800	435	1,235
Cocheco	6	0	0	1,400	1,180	130	2,450	2,580
Others	3	0	0	0	1,060	0	1,060	1,060
MAINE-NEW HAMPSHIRE COASTALS	0	8	0	3,250	1,499	3,450	1,299	4,749
Mousam	0	8	0	3,250	1,499	3,450	1,299	4,749
	Plants							
GRAND TOTAL MAINE BASINS	219		365,280	275,126	36,434	265,846	410,994	676,840

* Canadian power sites are omitted.

TABLE VII-A: EXISTING STORAGE

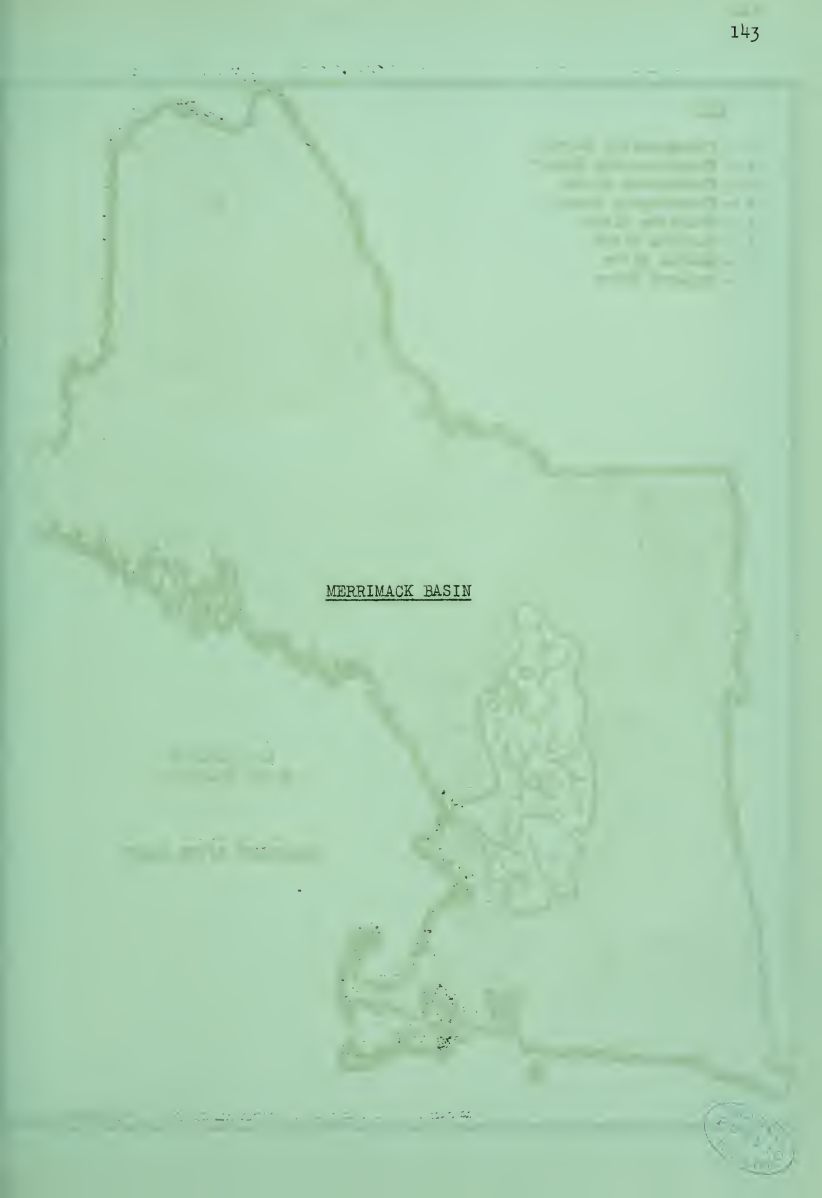
MAINE BASINS

	Drainage Area Sq.Mi.	Water Surface Sq.Mi.	Storage Capacity Acre-feet	Storage Equivalent Inches of Runoff
St. John River				
Estimated Total	26,000	--	For log driving only	--
St. Croix River				
East Grand Lake	146	23.7		
Spednik Lake	448	22.8		
Estimated Total, East Branch	644	48.	287,000	8.3
Sysladobsis Lake	59	9.9		
West Grand Lake	220	23.5		
Big Lake	--	16.3		
Estimated Total, West Branch	674	82.	298,000	8.1
Estimated Total St. Croix River	1,473	130.	585,000	7.3
Eastern Maine Coastal Basins				
Machias River Basin	495	24.6	77,000	2.9
Union River Basin	496	46.8	199,000	7.7
Other Coastal River Basins	1,559	81.4	206,000	2.5
Estimated Total	2,550	153.	472,000	3.5
Penobscot River				
East Branch				
Allagash Lake	96	7.0	30,300	
Chamberlain and Telos Lakes	270	21.3	131,500	
Webster Lake	274	.9	5,800	
Second and Grand Lakes	470	6.6	44,900	
Est. Total-Grand Lake Outlet	470	36.	212,500	8.5
Estimated Total-East Branch	1,180	41.	233,000	3.7
West Branch				
Canada Falls	460	--	22,900	
Seboomook Lake	530	8.5	77,800	3.5
Caucomgomoc Lake	171	7.0	31,100	3.4
Chesuncook Lake	1,410	43.0	688,000	
North Twin System	1,880	24.9	378,000	11.9
Millinocket Lake	106	13.9	56,000	9.9
Estimated Total-West Branch	2,120	90.	1,280,000	11.3
Mattawamkeag River Basin	1,500	22.	89,000	1.1
Piscataquis River Basin	1,500	28.	217,000	2.7
Passadumkeag River Basin	383	16.	115,000	5.6
Estimated Total (Penobscot Basin)	8,937	200.	1,948,000	4.1

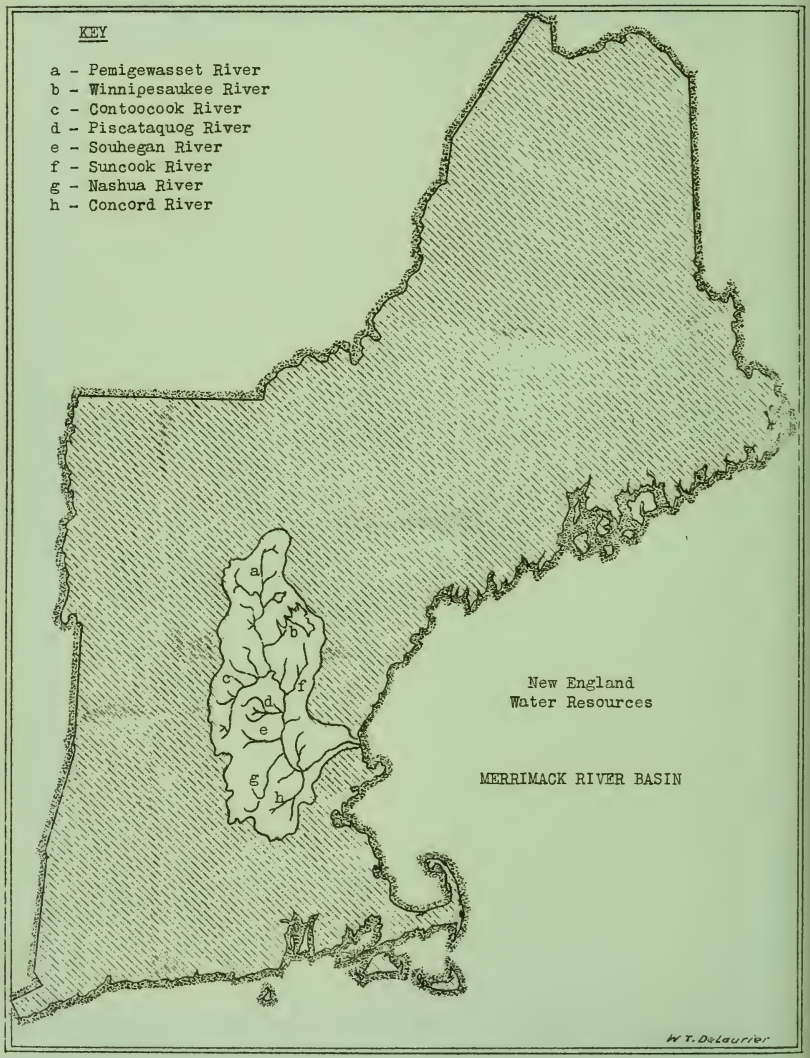
	Drainage Area Sq. Mi.	Water Surface Sq. Mi.	Storage Capacity Acre-feet	Storage Equivalent Inches of Runoff
Kennebec River				
Wood and Attean Ponds	320	7.8	8,000	
Brassua Lake	708	15.1	206,000	
Roach River Basin	117	8.0	29,000	
Moosehead Lake	1,240	117.0	542,000	11.9
Moxie Pond	80	3.	16,100	3.8
Pierce Pond	18	2.3	14,300	14.7
Wyman Lake	2,710	4.8	199,000	7.0
Sebasticook River Basin	975	13.0	119,000	2.3
Messalonskee River Basin	205	18.0	96,000	8.8
Cobbosseecontee River Basin	221	14.0	46,000	3.9
Estimated Total	6,190	--	1,250,000	4.1
Androscoggin River				
Kennebago Lake	112	2.7	17,600	2.9
Rangeley Lake	90	9.8	24,300	
Mooselookmeguntic Lake	405	26.0	194,000	
Richardson Lake	509	13.1	134,000	13.6
Sawyer Lake	233	14.6	220,400	17.7
Umbagog Lake	1,095	15.0	71,800	
Estimated Total at Errol Dam	1,095	82.	675,000	11.6
Estimated Total-Androscoggin R.	3,510	--	739,000	4.0
Presumpscot River				
Songo River Basin	244	16.3	76,500	
Sebago Lake	436	52.1	252,000	14.1
Estimated Total	727	80.	360,000	9.3
Saco River				
Conway Lake	--	2.0	13,100	
Moose Pond	26	--	16,300	
Ossipee Lake	327	6.1	19,900	1.1
Pine River Pond	13	.2	9,600	
Estimated Total	1,730	--	85,000	.9
Piscataqua River				
Great East Pond	30	2.6	20,600	
Three Ponds (Milton)	112	1.3	9,800	5.0
Bow Lake	13	1.8	11,500	16.5
Pawtuckaway Pond	21	1.4	10,800	9.7
Estimated Total	1,030	--	65,000	1.2
Maine-New Hampshire Coastal Basins				
Estimated Total	750	--	9,580*	.2

*Total in Maine only

NOTE: Storage equivalent, in inches of runoff, is computed on a basis of all storage above point in question.



MERRIMACK BASIN


KEY
a - Pemigewasset River
b - Winnipesaukee River
c - Contoocook River
d - Piscataquog River
e - Souhegan River
f - Suncook River
g - Nashua River
h - Concord River
a
b
c
d
e
f
g
h
New England
Water Resources
MERRIMACK RIVER BASIN
W T. DeLaurier

MERRIMACK BASIN

GENERAL DESCRIPTION

The Merrimack Basin, the fifth largest in New England and, as an interstate basin, surpassed in size by the Connecticut only, comprises an area of 5000 square miles, 1200 of which are in Massachusetts and 3800 in New Hampshire. The length of the basin at the longest point is 150 miles, while the width is about 50 miles. The river has its headwaters in the White Mountains in the State of New Hampshire and flows southerly through the central part of that state to a point in Massachusetts just below the state line, where it turns abruptly to the east and flows generally northeast, approximately parallel to the state boundary and about four miles south of it for a distance of about 45 miles to Newburyport, where it enters the Atlantic Ocean. The total length of the main stream is 110 miles, of which the last 22 miles are tidal.

The headwaters region of the river has a rugged topography characterized by narrow valleys and steep slopes rising to peaks from 3000 to 5000 feet in altitude. In the east central and southeastern portions, the topography becomes hilly, and rolling country is general. In the western part of the watershed the topography is irregular, with rolling hills of 1000 to 1200 feet in height. The watershed line is well defined except in the coastal lowland section, where the divide sometimes becomes indefinite.

The rock structure is almost entirely granite or gneiss covered with glacial sand and gravel. Large drumlins are common in the southern part of the basin. Deposits of a fairly rich sandy loam characterize the Massachusetts section of the valley.

Twenty per cent of the basin area is in cleared farmland, almost all of which is found in the bottom lands in New Hampshire or scattered through the rolling lands in Massachusetts. There is practically no virgin timber in the basin, but the upper mountainous portion in the western and northern part contains areas which are forested with good second and third growth of spruce and northern hardwoods. Although formerly the cover was white pine and spruce, much of the woodland now standing is mixed hardwood, with scattered stands of coniferous trees. About 183 square miles, or 3.7% of the total area, is water surface. More than half of this area is concentrated in four lakes located in the headwaters region.

The annual precipitation in the basin averages about 42 inches, varying from 37 to 44 inches, with somewhat higher amounts in the mountains. The monthly rainfall is fairly uniform in all parts of the basin, although records at the northern stations show a tendency toward heavier precipitation in the summer and autumn. The average seasonal rainfall is shown by the records to be 9.9 inches in the winter; 10.2 inches in the spring; 11.2 inches in the summer; and 10.7 inches in the autumn. Temperatures vary considerably in the northern inland portions of the basin and the southern coastal portions, the winter averages ranging from 16° to 26° and the summer ones from 62° to 63°.

Discharge records are obtained by the U. S. Geological Survey in cooperation with the states at numerous gaging stations located on the main river and its tributaries. Detailed data for these stations can be found in the Water Supply papers of the U. S. Geological Survey. The figures in Table III are summarized from the Survey's various Water Supply papers covering Part I, North Atlantic Slope Drainage Basins, and from unpublished records for 1936 in the office of the District Engineer at Boston.

Hydrographs showing the monthly average runoff during the last 15 years of record are shown on Chart 5 for Lowell, Massachusetts; Franklin Junction and Plymouth, New Hampshire. The 1922 record for Lowell is a modified Lawrence record for that year, as the Lowell station was not put into operation until 1923. The mean annual discharge at these three stations, expressed in cubic feet per second per square mile is: Lowell, 1.50 (drainage area, 1424 sq.mi.); Franklin Junction, 1.81 (drainage area, 1510 sq.mi.); and Plymouth, 2.18 (drainage area, 622 sq.mi.).

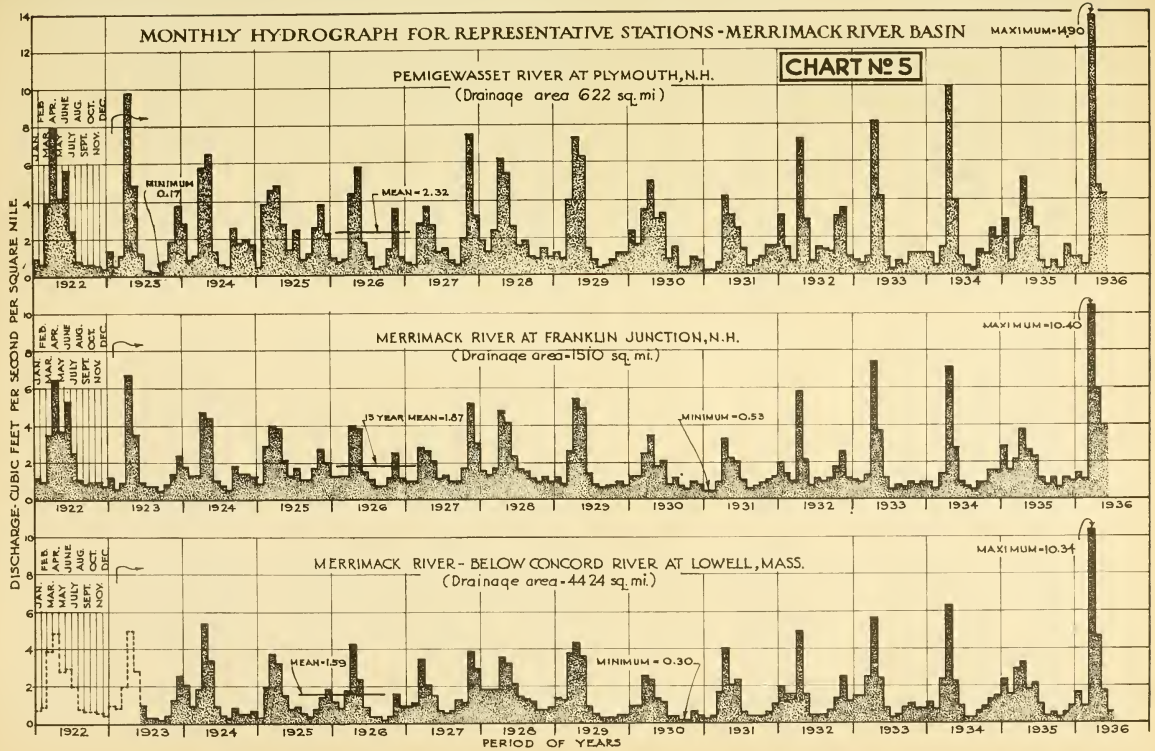
Main River and Tributaries

The main river is formed at Franklin, New Hampshire by the confluence of the Pemigewasset and Winnipesaukee rivers. In addition to these rivers the principal tributaries are the Contoocook, Suncook, Piscataquog, Souhegan, Nashua and Concord rivers. Of these the Concord River drains an area lying wholly in Massachusetts; while the Nashua River drains a large area in central and northern Massachusetts and, flowing into New Hampshire, discharges into the main river in that state about five miles above the Massachusetts boundary. The drainage areas of the principal tributaries are given in the following table:

TRIBUTARY	ENTERS AT	DRAINAGE AREA - Sq. Mi.
Pemigewasset	Franklin	1085
Winnipesaukee	Franklin	435
Contoocook	Penacook	766
Piscataquog	Manchester	214
Souhegan	Merrimack	225
Suncook	Suncook	252
Nashua	Nashua	615
Concord	Lowell	301

The Pemigewasset River rises in Echo Lake in Franconia Notch at an elevation of about 2000 feet and flows in a southerly direction about 70 miles to Franklin, where it joins the Winnipesaukee River to form the Merrimack. Its drainage area of 1085 square miles contains the most rugged and least developed part of the Merrimack Basin. The two largest lakes in the Pemigewasset basin are Squam and Newfound Lakes, controlling together 150 square miles of drainage area.

The Winnipesaukee River has its source at the outlet of Lake Winnipesaukee and flows for ten miles through a series of enlargements known as Lake Paugus, Lake Opechee, Lake Winnisquam, Lower Winnisquam and Silver Lake to its junction with the Pemigewasset at Franklin. The aggregate water surface of these six lakes is about 85 square


MONTHLY HYDROGRAPH FOR REPRESENTATIVE STATIONS - MERRIMACK RIVER BASIN
CHART No 5
PEMIGEWASSET RIVER AT PLYMOUTH, N.H.
(Drainage area 622 sq. mi)
MAXIMUM-1490
MINIMUM 0.17
MEAN = 2.32
MERRIMACK RIVER AT FRANKLIN JUNCTION, N.H.
(Drainage area-1510 sq. mi.)
MAXIMUM=10.40
15 YEAR MEAN=1.87
MINIMUM = 0.53
MERRIMACK RIVER - BELOW CONCORD RIVER AT LOWELL, MASS.
(Drainage area - 4424 sq. mi.)
MAXIMUM=10.34
MEAN=1.89
MINIMUM = 0.30
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936
DISCHARGE-CUBIC FEET PER SECOND PER SQUARE MILE
PERIOD OF YEARS

miles, to which total Lake Winnipesaukee contributes 72 square miles. Lake Winnipesaukee controls a drainage area of 360 square miles, which is about 83% of the drainage area of the Winnipesaukee River.

The Contoocook River drainage area is, with the exception of the Pemigewasset, the largest tributary area of the Merrimack. The river rises a few miles north of the Massachusetts line and flows north and northeast about 55 miles to Penacook where it joins the Merrimack. The most rugged section of its drainage area of 765 square miles, composed of rolling country with scattered mountains and many small lakes, is in the north. This portion is drained by the Blackwater River, an important tributary of the Contoocook.

The Suncook River rises in Suncook ponds a few miles south of Lake Winnipesaukee and flows southeast about thirty miles to the Merrimack River at Suncook, five miles below Concord. The basin comprises an area of 252 square miles of rolling country which is predominantly agricultural.

The Piscataquog River drains an area of about 215 square miles in northern Hillsborough County. The north and south branches, each about 15 miles long, unite near Goffstown, 9 miles west of Manchester, where the Piscataquog joins the Merrimack.

The Souhegan River rises a short distance south of the state boundary line in Northwestern Middlesex County, Massachusetts, and flows northeasterly and easterly a distance of 30 miles to its confluence with the Merrimack River at Merrimack, about half way between Manchester and Nashua. Its drainage area of 223 square miles (of which 5 are in Massachusetts) has an irregular topography and is an agricultural and wooded country. Included in the basins of the Souhegan and the Nashua Rivers is the Nashoba Fruit Belt, best known apple and peach region in New England. The Nashua River basin has an area of 516 square miles, of which over 90% is in Massachusetts. The north and south branches unite near Clinton to form the main river, which flows northerly across the state line and then northeast to its junction with the Merrimack at Nashua, a total distance of 65 miles. The waters of the South Branch are impounded in Wachusett Reservoir, the principal source of Metropolitan Boston water supply. The north branch rises in the irregular hills of northern Worcester County and flows southeast through the industrial and agricultural region to join the south branch five miles below Wachusett Reservoir.

The Concord River, the only important tributary of the Merrimack which is entirely in Massachusetts, drains a predominantly suburban manufacturing and farming area of about 300 square miles. Formed in east central Massachusetts by the junction of the Assabet and Sudbury rivers, it flows northeast about 15 miles into the Merrimack River at Lowell.

HUMAN OCCUPANCY

Population Of the total basin population of 811,000 (as of 1930) there are about 256,000 in New Hampshire and 555,000 in Massachusetts; over three-quarters of the total population is found in the southern industrialized portion of the basin, where the average density is over 400 per square mile in contrast to about 70 per square mile in the northern area.

The population is nine-tenths urban. Cities and towns of 10,000 or over, according to the 1930 census, are as follows:

Name	Population	Name	Population
Lowell, Mass.	100,234	Leominster, Mass.	21,810
Lawrence, Mass.	85,068	Methuen, Mass.	21,069
Manchester, N. H.	76,834	Marlboro, Mass.	15,587
Haverhill, Mass.	48,710	Newburyport, Mass.	15,084
Fitchburg, Mass.	40,692	Clinton, Mass.	12,817
Nashua, N. H.	31,463	Laconia, N. H.	12,471
Concord, N. H.	25,228	Natick, Mass.	13,589
Framingham, Mass.	22,210	Amesbury, Mass.	11,899

On Map 7 are shown cities and towns that gained or lost population between 1920 and 1930. Most of those that gained lie in the southern end of the basin. The largest industrial cities in this section, however, showed losses in that period, due principally to the decline in the textile industry. In this group are Lowell, Lawrence, Haverhill, and Fitchburg, in Massachusetts, and Manchester in New Hampshire. By 1935 Fitchburg regained its 1920 population, Haverhill and Lawrence gained over 1930 and Lowell showed no further loss. Manchester suffered through the inactivity and final failure, in 1936, of the Amoskeag Mfg. Co., its principal industry. The mill buildings have since been taken over by a local corporation, and about half the space has been leased to various industrial enterprises. Nashua and Concord in New Hampshire, Framingham and Leominster in Massachusetts, and other smaller industrial centers not entirely dependent on textile manufacturing showed growth between 1920 and 1930.

The Merrimack basin gained between 1920 and 1930 about 41,000 in population, or 5.3%. In the same period there was a 5.% gain in New Hampshire as a whole, and 10.4% in Massachusetts as a whole. In spite of losses in the large cities in the Massachusetts section, this region of the basin accounted for most of the growth. Past trends indicate that urban centers will gain, and that in the larger ones the growth will occur in the peripheral areas. On the basis of an estimated population increase of about 7% by 1960 in the state of New Hampshire, and of about 10% in Massachusetts, only moderate gains in the population of the basin are anticipated. Urban gains will be reflected in losses in the thinly-settled rural regions.

Agriculture The principal agricultural activities are dairying, poultry raising, fruit growing, and small-scale general farming. Near the manufacturing communities part-time farming is widely practiced. The most productive farm area is in the southern part of the basin, where the value per acre is the highest for farm land anywhere in Massachusetts.

In the northern section values are lower and, except in the river valleys, land is of such inferior quality that farming is unprofitable. The rural communities lost heavily in population between 1900 and 1930 due to the attraction of industrial opportunities in the larger cities.

Except in the specialized fruit-growing belt and garden truck areas in the southern section, the possibilities for rural development in the basin are apparently in the field of supplying the needs of visitors seeking recreation in the northern areas. Any increase in farming will probably be on the outskirts of manufacturing centers and in the form of specialty and part-time farming. Many rural communities remote from industrial centers will very likely continue to lose population. There is a definite need for investigation to determine the desirability of applying both the preventive measures of rural zoning ordinances and the constructive effects of a rural land-use program if these towns are not to become acute problem areas. A rural land use zoning enabling bill was introduced into the New Hampshire legislature at its current session; was passed by the Senate, but was lost in the House.

Industry The southern part of this region, one of the oldest and most highly developed industrial sections of New England, contains along the Merrimack River and its tributaries important manufacturing cities - Manchester, Nashua, Lowell, Lawrence, and Haverhill. In addition there are many smaller manufacturing cities and towns throughout the basin, especially in its lower part. The principal industry in Lowell and Lawrence is textile manufacturing, and until recently this was true of Manchester, New Hampshire, which contained the Amoskeag Company, the world's largest textile plant. Shoes, paper and many other products are manufactured throughout the lower half of the basin.

The decline of manufacturing in this region during the depression resulted largely from the loss of textile business. This decrease, which began some years earlier, has continued to date. The outstanding example is that of the Amoskeag Mfg., Co. in Manchester, which closed permanently in 1936, thus throwing about 8000 people out of work. State and commercial industrial organizations, however, in both New Hampshire and Massachusetts are studying the problem of reviving their present industries and establishing new ones, and substantial progress is being made toward recovery. One of the objects is to broaden the field of manufacturing, which has comprised principally textiles, pulp and paper and leather products, by introducing diversified lines in order to establish more stable industrial conditions. On the whole, there are indications of a slow but definite industrial recovery.

Mining With the exception of a few stone quarries there are no important mining activities in this watershed.

Lumbering Lumbering operations are on a comparatively small scale and their special economic importance lies in the revenue derived from woodlot cuttings. There is also a moderate amount of timber cut under supervision in federal and state reserves in the northern end of the basin.

There are two possible developments in prospect for this region. The first is through improved methods of utilizing public forest lands and in the management of private woodlots; the second is through the dedication to scientific silviculture of abandoned farm land and land unsuited to agriculture. A land-use program and rural zoning enabling legislation will be necessary to achieve the second development.

Recreation Recreation is an important industry in the northern section. The lakes of this region, notably Winnipesaukee, attract thousands of summer visitors, many of whom are permanent summer residents. Winter sports bring another seasonal influx of outsiders. As a source of income, the recreation industry is of great economic importance to those of the year-round inhabitants left stranded by the agricultural and industrial decline in various sections of this region.

Transportation Tidewater extends to two miles above Haverhill, which is about twenty miles up the Merrimack River from the ocean. A seven-foot channel provides for water transportation to that city. Coal and petroleum are the principal items of a traffic that is of only moderate volume.

A network of good highways covers the entire basin except in certain mountainous portions near the Pemigewasset headwaters. However, many of the major highways are no longer adequate to meet traffic requirements. The State Planning Boards of New Hampshire and Massachusetts and the New England Regional Planning Commission have recommended construction of modern arteries across the southern part of the basin between Boston and Gardner; between Worcester, Massachusetts and Dover, New Hampshire; from Boston to White River Junction by way of Manchester and Concord; and along the Merrimack Valley from the Massachusetts - New Hampshire state line to the White Mountain National Forest.

Due to the density of population in this area, the Merrimack River basin is covered with a network of railroad lines. Many of the minor branches are now abandoned, and present trends indicate the discontinuance of service on many more and the substitution of bus lines. Of the through routes in this basin the following may be considered the most important: Fitchburg division from Boston to the west; Concord division from Boston to northern New Hampshire, Vermont and Canada; Portland division from Boston through Lawrence to Portland and the Maritime Provinces; New York-to-Maine line through Worcester, Lowell and Lawrence.

The Merrimack basin is crossed by the airway from Boston to Burlington, Vermont and Montreal, with scheduled service and stops at Manchester and Concord, New Hampshire. Other through routes which will serve recreational areas in New Hampshire are under consideration. Airways from Concord to northern points are also being studied. There has been considerable activity in the use of seaplanes, centering at Lake Winnipesaukee.

While the basin is, in general, well supplied with landing fields, there are a few areas where additional facilities would be desirable, and improvement of many of the existing fields is needed.

WATER USE AND CONTROL

Pollution One of the most serious pollution problems in New England is found in the Merrimack River basin, particularly along the main stem in Massachusetts. The untreated sewage and large volumes of industrial wastes from the cities of Lowell, Lawrence and Haverhill and a number of smaller cities and towns in Massachusetts produce conditions in the river which are highly objectionable. The worst sanitary conditions are found in the vicinity of Haverhill, where the combined effects of sewage and foul industrial wastes brought down from the upstream cities result in a critical situation which at times becomes so serious as to be termed a gross nuisance.

The main river and its tributaries receive untreated sewage from 42 communities through organized sewer systems discharging directly into the streams. Thirty of these systems are in New Hampshire and 12 in Massachusetts. Of those communities which have systems provided with treatment works, ten are in Massachusetts, and one in New Hampshire (New London). Two of the Massachusetts communities are on the Nashua River and 8 are in the Concord River area. There will shortly be a third on the Nashua River when the plant at Leominster is completed.

The daily discharge from the New Hampshire systems amounts to approximately 10,725,000 gallons. Of this amount, Manchester, Concord and Nashua contribute over three-quarters, the figures being respectively, 3,700,000, 2,200,000 and 1,750,000 gallons per day. 31,850,000 gallons per day are discharged into the river or its tributaries by Massachusetts systems, 20,200,000 gallons of which are untreated and 11,650,000 gallons treated. Lowell, Lawrence and Haverhill contribute untreated sewage at the rates of 5,520,000, 5,850,000 and 3,840,000 gallons per day, respectively. The estimated total daily discharge of sewage and industrial waste from all the cities and towns in Massachusetts bordering the main stem amounts to 62,000,000 gallons.

Starting with the Pemigewasset and Winnipesaukee Rivers, most of the tributaries of the Merrimack River receive pollution in some form. The tributaries of the Pemigewasset entering above North Woodstock are free from pollution, but a short distance above North Woodstock considerable pollution is received in the Pemigewasset itself through the discharges of pulp waste at Lincoln. Evidence of this discharge is noticeable along the edges of the stream as far as the intake of the Franklin Water Works, more than fifty miles below the point of discharge. This protracted extent of polluted conditions is due to the slow decomposition and elimination of pulp mill wastes which make the purification of the water more difficult than do most types of industrial and domestic wastes.

The appreciable degree of pollution along the river's course is of significance since the increase in recreational use of the stream is undoubtedly retarded by this pollution.

From its source in Lake Winnipesaukee, the Winnipesaukee River flows through five lakes to the point of confluence with the Pemigewasset. Along its course, it receives sewage from the city of Laconia and from the villages of Tilton and Franklin Falls. Lake Winnisquam, serving as a detention basin, has a mitigating effect on the sewage from Laconia, because such a large body of water provides an unusual degree of self-purification of the stream. Although comparable

analyses of the Pemigewasset and Winnipesaukee Rivers show the Winnipesaukee to be the less polluted, nevertheless the need exists to render the Winnipesaukee River distinctly better than it is.

The Contoocook River, entering the Merrimack at Penacook, carries the diluted sewage from eight communities. This sewage and the industrial wastes from various manufacturing plants cause pollution which makes the river unsatisfactory for recreational use inasmuch as the river water is rendered unsafe for bathing and noxious to fish life. There may be too many obstacles to make practical any attempt to restore this stream to a condition suitable for recreation, but serious attention might well be given to prevention of overloading the stream with pollution to the extent that a nuisance is created. Such a conservative attitude concerning the problem of pollution abatement is undoubtedly the most practical and reasonable one to take on streams which from long usage may be characterized as industrial, or which drain the more populous sections of the area.

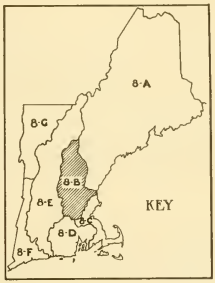
Several instances occur where lake waters are polluted. Squam Lake receives no sewage directly, but with over 200 cottages around its shores a potential condition of pollution exists. Lake Winnipesaukee is the depository of sewage from the Wolfeboro system and also receives a considerable amount of sewage and untreated effluent through the storm drains in the town of Meredith. The resulting pollution of the lake water is a menace to the several communities bordering on the lake as well as to numerous tourist places and juvenile camps where the lake water is used for drinking purposes. Both situations are sufficiently urgent to require remedial measures. Upper Winnisquam Lake is practically ruined for recreational use by the discharge of Laconia sewage. This discharge is also detrimental to the recreational uses of the downstream lakes.

New Hampshire, being so largely a recreational state, might justifiably turn its attention to the removal of all material pollution from its lakes and ponds as its first objective in a program for pollution abatement.

While the sanitary conditions of the Merrimack River in Massachusetts are not seriously affected by the absence of treatment at the three New Hampshire cities, Concord, Manchester and Nashua, investigations to determine the effect of the discharge of sewage and waste at these places might well be undertaken within the next few years and plans developed for the abatement of objectionable insanitary conditions. The immediate problem, however, is the improvement of the lower river in Massachusetts, and the New Hampshire cities cannot be expected to construct treatment works, except for their own protection, until there is assurance that the objectionable conditions in Massachusetts will be rectified.

In the Nashua River, draining a large area in central and northern Massachusetts, the nuisances of pollution are becoming more acute each year due to the increasing amounts of industrial wastes entering the river at Fitchburg. These wastes, together with sewage from Leominster, have been noticeable in the North Branch of the river down to its mouth, while the South Branch is polluted below Clinton. At

MAP Nº 8-B



Legend

- ◇ SEWAGE SYSTEM - NO TREATMENT
- ◆ SEWAGE SYSTEM - TREATMENT
- ○ CONSTRUCTION PROJECT

NOTE. POLLUTION INVESTIGATION PROJECTS FOR: MERRIMACK VALLEY IN NEW HAMPSHIRE; MAIN RIVER IN MASS; NASHUA RIVER IN MASS.

NEW ENGLAND WATER RESOURCES

SEWAGE AND POLLUTION

MERRIMACK BASIN

DEC. 1 1937

SCALE

8 0 8 16

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

Groton the main stream in unsatisfactory for recreational uses largely because of the polluted discharge from the North Branch.

The situation at Leominster will soon be corrected by the construction of a sewage treatment plant which will be completed in 1938. The removal of the Leominster sewage makes it desirable that any foul industrial wastes from the North Branch be removed also; studies are needed to determine if such removal is economically feasible.

A recent sanitary survey of the river has shown fully the pollution of the Nashua River by both domestic and industrial wastes, the latter being particularly heavy at Fitchburg. The data already collected indicate that further studies should be undertaken in the near future by the state health authorities, acting under appropriate legislation, for the purpose of developing a constructive program for the improvement of this river. Steps to encourage industrial and recreational improvements in this valley should be taken at an early date.

Notwithstanding the pollution, both domestic and industrial, received from the several cities and towns along the main river and its tributaries, the river, as it crosses the state boundary into Massachusetts, is not, except for water supply uses, objectionable from a sanitary point of view at present.

The pollution resulting from the discharge of sewage and industrial wastes at Lowell and the surrounding towns is not greatly in evidence during the periods of high flow, but in dry weather flow it is objectionable along the banks and bed of the river. Between Lowell and Lawrence, the river flows through the long mill-pond formed by the dam at Lawrence and, in this stretch, there is a decrease in the quantity of dissolved oxygen present; also the quantity of solids and organic matter in the river is reduced.

At Lawrence and its neighboring towns of Methuen, Andover and North Andover the sewage discharged into the river contains sufficient objectionable matter to cause serious pollution in the stream. At Haverhill the dissolved oxygen decreases to an alarming extent and here additional domestic sewage and industrial wastes enter an already polluted stream.

Tidewater extends up the river to a point about two and a half miles above Haverhill Bridge and, in this reach of the river, on the flood tide, water flows upstream past the city of Haverhill some two miles above Haverhill Bridge, bringing with it some of the sewage discharged at Haverhill to meet that flowing from Lawrence, while on the ebb flow, the polluted waters are not carried far enough downstream to prevent their return on the following flood tide. Consequently the sewage and wastes tend to concentrate in the neighborhood of Haverhill and for several miles downstream. The presence on the bed and banks of the stream of deposits of foul organic matter causes offensive odors to rise from the waters, especially in warm weather, when a considerable portion of the bed of the river is exposed at low tide. The polluted condition at this point is also manifest by the floating masses of sludge carried to the surface of the river by the gasses of decomposition. Hence pleasure boats in this part of the river are badly fouled by the water.

At the lower end of the Middle Ground, a broad stretch about nine miles below Haverhill, conditions improve considerably, due to the additional dilution provided by the sea water running with the tides.

From Haverhill to the mouth of the river only a comparatively small amount of pollution occurs from the sewage of Salisbury and Newburyport. However, in an investigation made by the State Health Department in 1934, it was determined that the pollution from these two communities constituted 62.9% of the total pollution contributed to the shellfish areas at Newburyport. Lowell, Lawrence and Haverhill together contributed 26.8%, the remaining 10.3% being contributed by the towns of Chelmsford, Dracut, Methuen, Andover, North Andover and Amesbury.

In 1924, the Massachusetts Department of Public Health made an investigation of the main river and its tributaries in the cities and towns of Massachusetts bordering on the river to determine the character and quantity of the sewage, drainage and industrial wastes discharged into the river. A further purpose of the investigation was to report on the feasibility and cost, either of collecting the domestic and industrial wastes by means of an intercepting trunk sewer which would discharge the collected sewage through an outlet into the sea at the mouth of the river, or of treating these wastes for removal of polluted matters at suitable works located at convenient points in the various cities and towns.

The results of the investigation indicated that the removal of the sewage by the trunk sewer would be the more effective and, in the long run, the more economical plan to adopt. The estimates for the trunk sewer and the individual works were, respectively, $10,000,000 and $8,400,000, based on prewar costs, but the annual cost of maintenance and operation of the treatment works would be about double the annual cost of maintenance and operation of the trunk sewer system. Consequently, the total cost of the trunk sewer system, including all capital charges, would be considerably less than the total cost, including the capital charges, of separate sewage disposal works.

In 1936 a legislative act (Chap. 420, Acts of 1936) was passed authorizing the establishment of the "Merrimack River Valley Sewerage District" to include all the territory of the cities and towns of Amesbury, Andover, Chelmsford, Dracut, Groveland, Haverhill, Lawrence, Lowell, Merrimack, Methuen, Newburyport, North Andover, Salisbury, Tewskbury, Tyngsboro and West Newbury. The district is to be managed and controlled by a board of five members appointed by the Governor. Its functions are to construct, maintain and operate for the district, subject to the approval of the State Department of Public Health, such trunk sewers and sewerage works as may be required to divert, dispose of or suitably treat sewage and other pollution originating in any of the cities or towns in the district.

The act carries the provision that unless, prior to January 1, 1938, the sum of $10,000,000 or such smaller sum as may be sufficient to accomplish all or a reasonable portion of the purposes of the act has been allocated by the Federal government, the act shall become null and void.

It would appear desirable for the State Department of Health to review the pollution problem in the Merrimack. It is evident, now, that disposal by dilution at sea will not be favored by communities at the mouth of the river and, furthermore, that primary treatment works, involving an additional construction cost of some three million dollars, would be required if the trunk sewer project were undertaken. It is doubtful if separate disposal plants for the individual communities would involve less cost. The population growth in the valley has been markedly less than was predicted in 1923. The estimated population of these cities and towns by 1935 was 432,860. According to the census of 1935, but 337,285 persons were then living in the valley, -- 95,575 less than predicted. The 1965 population estimate of 568,120 probably approaches 200,000 in excess of what the actual population will be. This discrepancy will undoubtedly modify the recommendations made fourteen years ago. Another element which should be considered is the effect upon the low water flow if any storage reservoirs are constructed in the upper basin. If, by regulation, a substantial increase in low season flow can be obtained, postponement of the construction of local disposal works may be made possible.

Summarizing the pollution problem in the Merrimack Basin, it is found that, beginning with the headwater tributaries, most of the tributaries of the Merrimack receive varying amounts of pollution in some form. The larger cities along the main river contribute large volumes of untreated sewage and industrial waste, the degree of pollution becoming most extensive in the Massachusetts portion of the river. Sewage treatment facilities in the upper basin conserve the unusual recreational advantages of this section, one of the most popular summer playgrounds in New England.

Many towns and villages in the Merrimack Basin are without public sewerage systems, but, in general, the construction of new sewer systems and extensions of existing systems are problems of individual communities, and the benefits of such works are for the most part confined to specific localities.

Water Supplies In general, throughout the Merrimack valley, water of good quality can easily be obtained from upland surface sources or from wells. Filtration is unnecessary except for improving the physical characteristics of the water. The existing supplies are about evenly divided between surface and underground waters: New Hampshire has a preponderance of lakes, ponds and small streams, while Massachusetts has more dug and driven wells.

The runoff from about 211 miles of the basin's drainage area is diverted from the basin, as 118 square miles tributary to the South Branch of the Nashua River is used for the water supply of the Metropolitan Water District and partly for the city of Worcester, also 75 square miles on the Sudbury River and 18 square miles tributary to Lake Cochituate are used for the Metropolitan Water District supply. The runoff is stored in nine reservoirs having a combined storage of 80 billion gallons and comprising Wachusett Reservoir on the South Branch of the Nashua River, Lake Cochituate and seven other smaller reservoirs on the Sudbury watershed. The average annual yield from the Sudbury area over a period of 61 years was 1.500 cubic feet per second, or 969,000 gallons per day, per square mile and the average for the driest six months during the same period was .606 cubic feet per second, or 391,200 gallons per day, per square mile. Corresponding figures for the Nashua River, over a period of 39 years are: average for whole year, 1.687 cubic feet per second, or 1,090,000 gallons per day, per square mile, and average for driest six months, .879 cubic feet per second, or 568,000 gallons per day, per square mile.

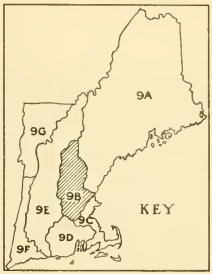
Ninety-nine communities in the basin are supplied with water by organized systems, 48 being in New Hampshire and 51 in Massachusetts. In New Hampshire thirty-three of the systems are publicly owned, twelve are privately owned and three are partly public and partly private. In Massachusetts, 46 communities have publicly owned supplies, four have private works and one is served by both private and public works.

On the whole, these communities are adequately supplied. In a few cases, improvements involving either the development of supplementary sources or the protection of the quality of the existing water supply are needed. In Massachusetts, the valley population has decreased materially in the past ten years, so that anticipated needs for extensions to water supplies have not been realized.

In a number of New Hampshire communities it will soon be desirable to install new water supplies or to extend existing ones. From the standpoints of sanitation and fire protection, certain communities now using individual wells should consider the feasibility of installing systems.

With the growing recreational use of water bodies, it is becoming of greater importance that attention be paid to the protection of water supplies, not only the lakes and ponds themselves, but also of the land areas tributary to the surface waters and to springs and wells.

MAP Nº 9B



Legend

- WELL, SPRING, SURFACE — NO TREATMENT
- WELL, SPRING, SURFACE — TREATED WITH DISINFECTANT
- WELL, SPRING, SURFACE — TREATED MECHANICALLY
- WELL, SPRING, SURFACE — MECHANICALLY TREATED AND DISINFECTED
- INSIDE SYMBOL OF SUPERIMPOSED SYMBOLS INDICATES TREATMENT OF ALL.
- SUGGESTED PROJECT
- • SUPPLIED BY THE METROPOLITAN BOSTON SYSTEM.

NEW ENGLAND WATER RESOURCES

WATER SUPPLIES

MERRIMACK BASIN

DEC. 1, 1937

SCALE

0 8 16

NOTE: INVESTIGATION PROJECTS FOR WATER SUPPLY REQUIREMENTS OF ALL TOWNS AND CITIES IN NEW HAMPSHIRE.

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE — DISTRICT NO 1
2100 FEDERAL BUILDING — BOSTON MASSACHUSETTS

Lowell is the largest community using driven wells for its supply. Its well-field is situated near Tyngsboro, close to the north bank of the Merrimack River. Tests have shown that under ordinary conditions the wells are not contaminated by seepage from the river. Following the flood of March 1936, however, between thirty and forty of the wells did show such contamination that it became necessary to cut them off temporarily from the supply system. The nominal capacity of the Lowell supply is about 10 million gallons per day, but the effective capacity of the wells is about reached when being drawn on at the rate of 5½ million gallons per day, the present average rate of consumption. In the dry season, it has been necessary to use water from a system of wells in the valley of Hales, or River Meadow Brook, known as the Cook and Hydraulic wells.

Within the past year the Cook wells have been cleaned, the field enlarged and a pumping station installed. This station will soon be in operation, and with the additional 2-million-gallon supply from these wells, the water needs of the city will be satisfactorily met for some time. Later, when a larger supply is needed, a well-field located on the south bank of the Merrimack River in North Chelmsford will probably be used to augment the supply.

The City of Lawrence is supplied chiefly with water drawn from the Merrimack River and subsequently treated by slow sand filters and chlorination. This supply is unsatisfactory owing to the badly polluted condition of the river caused by sewage and manufacturing wastes from the cities and towns along the river and its tributaries above Lawrence. Despite the fact that water can be made safe for drinking through purification by filtration and disinfection, the use of such water is more or less repulsive to the inhabitants. Steps should be taken to obtain a water supply from a source not subject to sewage contamination.

The daily water consumption at Lowell and Lawrence, the highest in the basin, amounts to about 5,500,000 gallons for Lowell and 6,800,000 for Lawrence, corresponding to a per capita consumption of 55 and 67 gallons per day, respectively.

Fitchburg has the highest per capita consumption in the basin -- 101 gallons per day. Water supply statistics for the cities and towns in the basin are summarized in Table V-B.

Another community in need of water supply extensions is the town of Methuen, which at present obtains its water from three groups of wells. In recent years the combined supply from these three sources has been inadequate for the town during dry seasons and it has been necessary to take water directly from the Spicket River. Studies have been made relative to extension of this supply by building a dam and reservoir at Peters Pond and by constructing a conduit to suitable treatment works and pumps to be installed at the Harris Brook pumping station.

An example of a community that needs a new supply because of contamination in the old is the town of Belmont, New Hampshire. The present source of supply is a brook. The conditions of the watershed are so unsatisfactory

that chlorination is inadequate to bring the water up to the desirable quality. The alternative -- use of artesian wells -- does not appear feasible because the water is highly impregnated with iron, and furthermore, the supply would be far from adequate. Attempts have been made to utilize a nearby brook as a new source which, with provision for rapid sand filtration for iron removal, would furnish a satisfactory supply. As the town officials and the owners of power rights on the brook have been unable to come to an agreement as to the use of the water, the project has been abandoned. However, the matter should be kept open because the present source is unsuitable and unsafe despite chlorination.

Flood Control The March, 1936 flood produced a peak discharge at Lawrence, Massachusetts, of 174,000 cubic feet per second, the maximum figure in a 91-year record. The nearest approach to this amount occurred in 1852, when a peak of 108,000 cubic feet per second was reached. The most recent flood prior to that of 1936 occurred in November, 1927, with a peak of 76,000 cubic feet per second. Although the 1927 flood was of extreme proportions, it has been exceeded nine times since 1846. Chart 6 shows the greatest daily flows occurring in each year of record. On Chart 7 these flows have been grouped according to the months in which they occurred, and it will be seen that floods are more prevalent in spring than at any other season of the year. A flood is less likely to occur in November (as in 1927) than in March or April, or even in May.

The 1936 flood produced some unusually high unit discharges on the main river and its tributaries. Table III-B based on records of the U. S. Geological Survey, gives the maximum discharges, together with the unit discharges, at the several gaging stations in the basin. Corresponding figures are given for the 1927 flood for such stations as were then in existence, and a comparison of the figures for the two years shows that the 1936 flows were considerably in excess of those of 1927. The highest recorded unit flow in 1936, amounting to 163 cubic feet per second per square mile, occurred at Lincoln, on the East Branch of the Pemigewasset River. The total runoff from the drainage area above this point was 19.89 inches for the flood period. The runoff at Plymouth was 15.05 inches and the maximum unit discharge was 105 cubic feet per second per square mile. Tributaries to the Pemigewasset produced discharges as high as 154 cubic feet per second per square mile. On the Mad and Runney rivers, the unit discharge in the 1927 flood exceeded that of 1936. Charts 8 and 9 show flood hydrographs at several stations for the 1927 and 1936 floods respectively.

In any flood the Pemigewasset Valley is subject to high discharges due to the steep sloping drainage area and river gradients. Plymouth is invariably the target for damaging floods, nor do Campton and Bristol escape high water experiences. The comparative steepness of the gradient of the Pemigewasset and its tributaries is shown on Profile 5.

In 1936 the tributaries of the Contoocook River yielded unusually high discharges, ranging from 112 cubic feet per second per square mile at Antrim, on the North Branch, to 132 cubic feet per second per

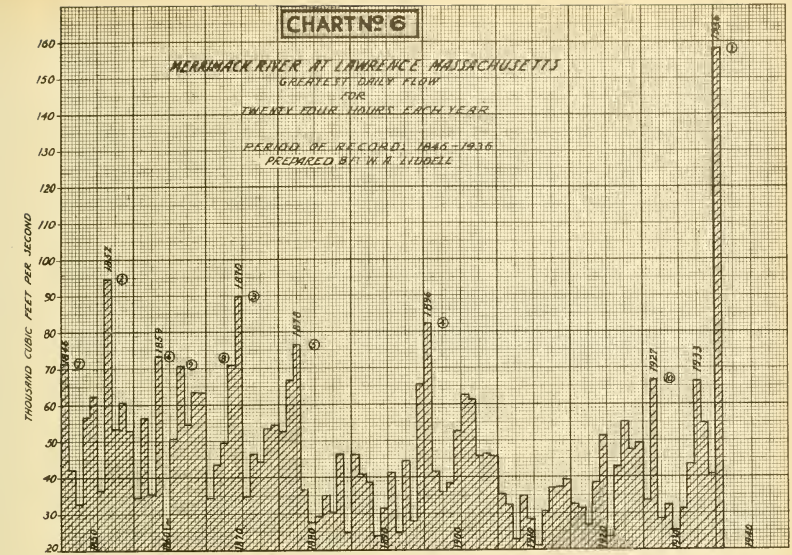


CHART № 6
MERRIMACK RIVER AT LAWRENCE MASSACHUSETTS
GREATEST DAILY FLOW
FOR
TWENTY FOUR HOURS EACH YEAR
PERIOD OF RECORD: 1846-1936
PREPARED BY W. A. LIDDELL
THOUSAND CUBIC FEET PER SECOND
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
1846
1852
1859
1870
1878
1896
1918
1927
1933
1936

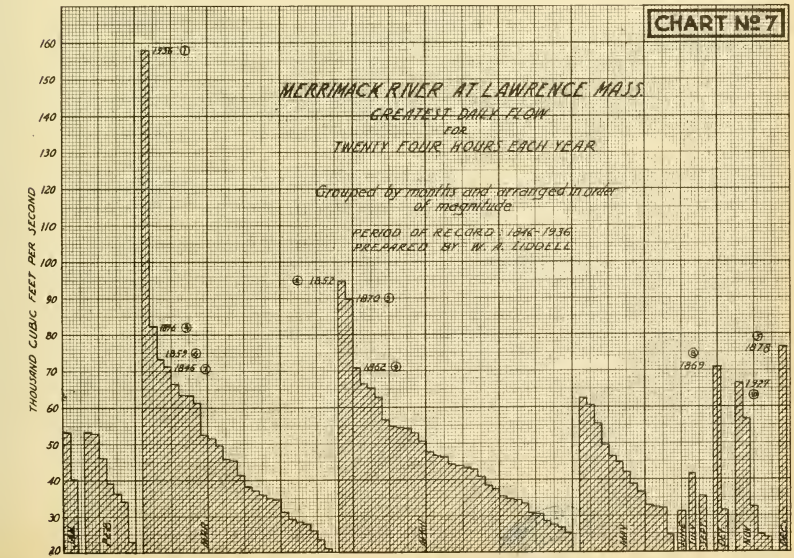


CHART № 7
MERRIMACK RIVER AT LAWRENCE MASS.
GREATEST DAILY FLOW
FOR
TWENTY FOUR HOURS EACH YEAR
Grouped by months and arranged in order of magnitude
PERIOD OF RECORD: 1846-1936
PREPARED BY W. A. LIDDELL
THOUSAND CUBIC FEET PER SECOND
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
1936
1852
1870
1846
1878
1859
1927
1869

square mile on the Blackwater at Webster. There are no available records of damages from floods prior to those of 1927. The 1927 damages, according to estimates obtained by the U. S. Army Engineers, amounted to $2,365,000. Of this amount, $800,000 damage was caused to railroads and $465,000 to highways. These damages were confined principally to New Hampshire, and for the greater part to the Pemigewasset Valley.

In 1936 the direct flood losses, as determined by the U. S. Army Engineers, were approximately $20,200,000 distributed over the entire area, with nearly $12,000,000 damage occurring in Massachusetts and $8,200,000 in New Hampshire. The indirect losses amounted to approximately $8,900,000 in Massachusetts, of which $3,800,000 were reported and additional unreported losses of $5,100,000 were estimated. The corresponding figure for New Hampshire was $5,360,000, of which $1,990,000 were reported and $3,370,000 estimated. The total losses, including the direct and the reported and estimated indirect losses for Massachusetts, were $20,800,000. Similar figures for New Hampshire amounted to $13,570,000, giving a grand total of $34,400,000. Industry suffered the greatest damages, taking a loss of $7,140,000 in Massachusetts, and $3,560,000 in New Hampshire.

Of the total flood losses in the entire Merrimack Valley, the Army Engineers estimated that those occurring in areas which could be controlled by storage reservoirs were $13,000,000 in Massachusetts and $10,900,000 in New Hampshire, or a total of $23,900,000; this would leave approximately $5,500,000 damages in areas which would not be benefited by the reservoirs under consideration. The Engineers' estimate of the total annual flood losses to be expected in the controllable reaches of the river is $469,600 in Massachusetts and $682,000 in New Hampshire, a grand total of $1,152,500. These figures were obtained by applying the computed expectancy of flood flows in the several reaches of the river to the losses attributable to succeeding increments of flood flow.

Possible measures for reducing future flood losses include channel improvements, diking, and construction of reservoirs. The first two usually prove to be justifiable only as local remedies. The enlargements of restricted passages in the river afford relief to the communities in the immediate vicinity, but are not as a rule of any particular benefit to communities downstream. Protection of the low bordering areas used for agricultural purposes by a system of dikes would cost more than the lands themselves, and the maintenance of these dikes over a period of years during which floods seldom occurred would make the project still more extravagant. However, in the case of a thickly populated section where considerable property is at stake, the cost of the flood wall may be economically justified, as at Haverhill, where the Engineers are constructing a flood wall along the north bank of the river. At Lowell,

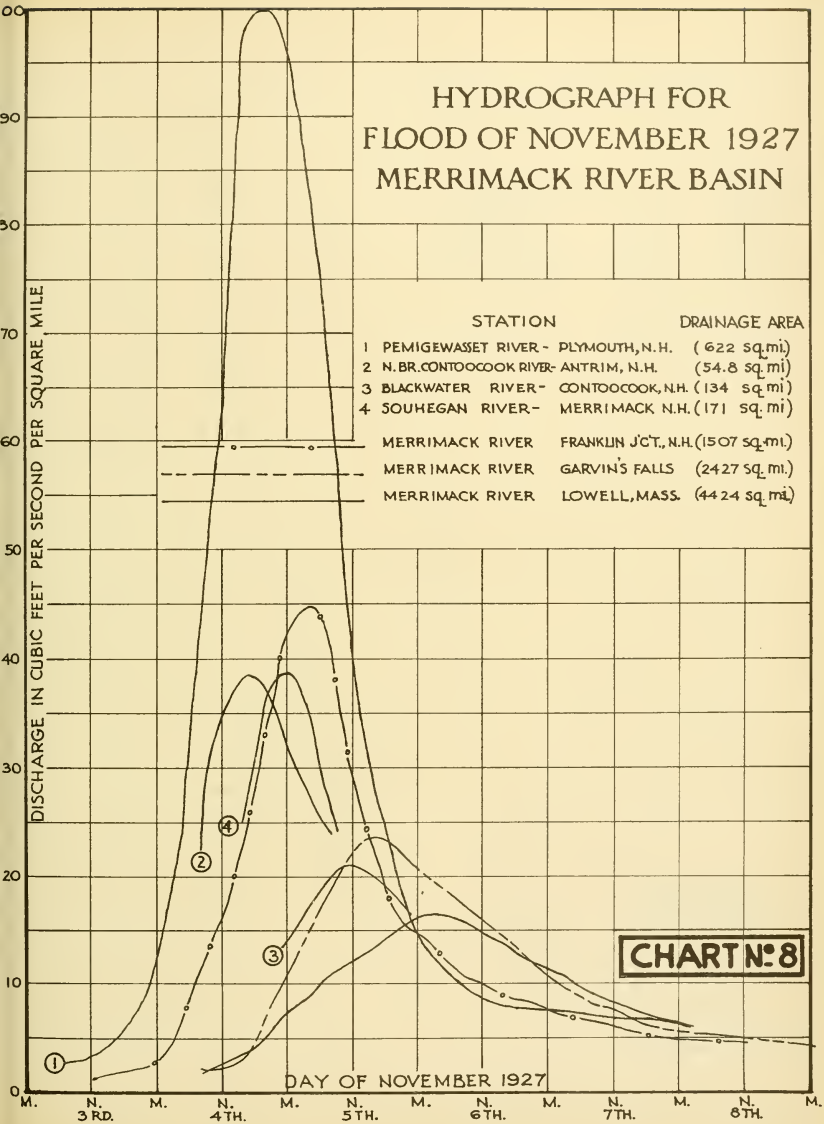
there is an excavation project for the enlargement of the water passages under the bridge just below Pawtucket Dam and the removal of ledge rock immediately downstream from the bridge to provide increased channel capacity and reduce flood stages. Likewise, extensive channel improvements being made at Fitchburg on the North Nashua River are expected to provide material relief.

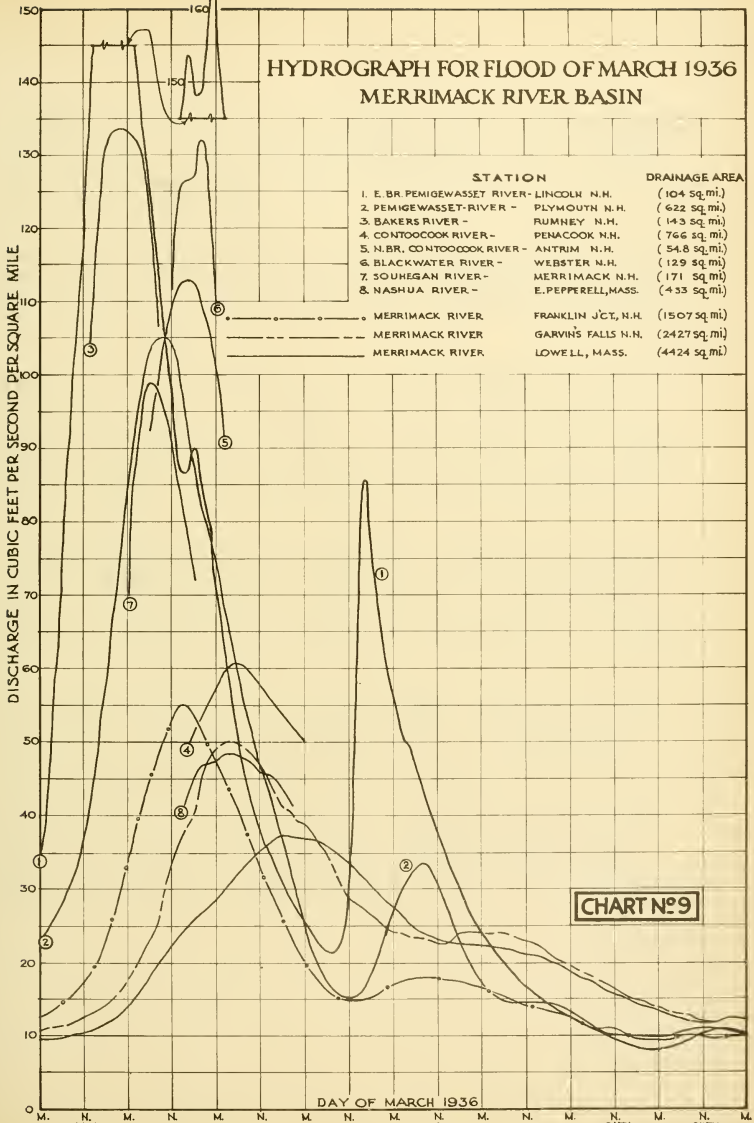
Storage reservoirs afford general relief and protection to the communities downstream and are the most economical means of reducing flood losses. There are sites on the tributaries of the Merrimack where storage can be developed sufficient to reduce the flood peaks to a point where damages will be relatively slight. In order to provide for the coordinated development of the river, final selection of reservoir sites should not be made without giving full consideration to all the possible uses to which the storage may be put. These uses include flood control, recreation, power and stream regulation, uses which are not inherently reconcilable and which therefore should be investigated concomitantly. In the Merrimack Valley increased storage is needed, not only for flood control, but also for stream regulation for existing power plants which are handicapped during the dry season by insufficient flow. The pollution conditions in the lower portion of the Merrimack would be greatly alleviated by increasing the low water flow with water stored in the reservoirs. Economic advantage might be taken of reservoirs for recreational uses provided such uses did not seriously affect other benefits. There are available upon the various tributaries, reservoir sites sufficient to make possible the degree of regulation required both for flood control and power use, as well as for other advantages.

Headwaters development and management form an important part of a complete plan for the improvement of this watershed. Some of the small storage sites available in the headwaters should be utilized to supplement and complete the program of larger reservoirs downstream to assist in the solution of local flood and water conservation problems. Proper management of the large forested areas is essential to provide a vegetative cover that will be most effective in assisting and supplementing the downstream development.

The existing storage in the Merrimack Basin is about 307,000 acre-feet, of which 275,000 acre-feet is in the Winnipesaukee, Newfound and Squam River watersheds. Lake Winnipesaukee, controlling 313 square miles at its outlet, affords the greatest part of the total storage with its 160,600 acre-feet capacity. Its water surface of 72 square miles represents about 68% of the total water surface of the storage reservoirs in New Hampshire.

The locations and capacities of the principal reservoirs are shown in Table VII-B.


HYDROGRAPH FOR
FLOOD OF NOVEMBER 1927
MERRIMACK RIVER BASIN
STATION
DRAINAGE AREA
1 PEMIGEWASSET RIVER - PLYMOUTH, N.H. (622 sq. mi.)
2 N. BR. CONTOOCOOK RIVER - ANTRIM, N.H. (54.8 sq. mi.)
3 BLACKWATER RIVER - CONTOOCOOK, N.H. (134 sq. mi.)
4 SOUHEGAN RIVER - MERRIMACK N.H. (171 sq. mi.)
MERRIMACK RIVER FRANKLIN J'C'T., N.H. (1507 sq. mi.)
MERRIMACK RIVER GARVIN'S FALLS (2427 sq. mi.)
MERRIMACK RIVER LOWELL, MASS. (4424 sq. mi.)
DISCHARGE IN CUBIC FEET PER SECOND PER SQUARE MILE
DAY OF NOVEMBER 1927
M. N. M. N. M. N. M. N. M. N. M. N. M.
3RD. 4TH. 5TH. 6TH. 7TH. 8TH.
CHART No. 8


HYDROGRAPH FOR FLOOD OF MARCH 1936
MERRIMACK RIVER BASIN
STATION
DRAINAGE AREA
1. E. BR. PEMIGEWASSET RIVER - LINCOLN N.H. (104 SQ. MI.)
2. PEMIGEWASSET RIVER - PLYMOUTH N.H. (622 SQ. MI.)
3. BAKERS RIVER - RUMNEY N.H. (143 SQ. MI.)
4. CONTOOCOOK RIVER - PENACOOK N.H. (766 SQ. MI.)
5. N. BR. CONTOOCOOK RIVER - ANTRIM N.H. (54.8 SQ. MI.)
6. BLACKWATER RIVER - WEBSTER N.H. (129 SQ. MI.)
7. SOUHEGAN RIVER - MERRIMACK N.H. (171 SQ. MI.)
8. NASHUA RIVER - E. PEPPERELL, MASS. (433 SQ. MI.)
MERRIMACK RIVER FRANKLIN J'CT., N.H. (1507 SQ. MI.)
MERRIMACK RIVER GARVIN'S FALLS N.H. (2427 SQ. MI.)
MERRIMACK RIVER LOWELL, MASS. (4424 SQ. MI.)
CHART Nº 9
DISCHARGE IN CUBIC FEET PER SECOND PER SQUARE MILE
DAY OF MARCH 1936
M. N. 18TH. M. N. 19TH. M. N. 20TH. M. N. 21ST. M. N. 22ND. M. N. 23RD. M. N. 24TH. M. N. 25TH. M.

Numerous storage reservoir projects located on the several New Hampshire tributaries have been considered and reports made on them. Consideration has also been given to increasing the capacities of Lake Winnipesaukee, Squam Lake and Newfound Lake so as to provide about 82,000 acre-feet of additional storage.

In 1917 and 1918 investigations of storage in the Merrimack Basin were made by the New Hampshire State Commission on Water Conservation and Water Power. Forty-four sites were examined and estimates of cost and probable benefits to power were made. These forty-four sites included all locations of any promise for increased storage, whether for power or for flood control.

In 1933 and 1934 investigations of four storage reservoir projects in the Merrimack Basin were made by private engineers for the state of New Hampshire. These projects were at Livermore Falls on the Pemigewasset River, Webster on the Blackwater River, Suncook Ponds on the Suncook River and Water Loom Pond on the Souhegan River. The Livermore Falls and Blackwater reservoir projects called for power developments at the dam sites. In all cases the use of storage was primarily for stream regulation and secondarily for flood control benefits.

Of these four reservoirs the Livermore Falls Project appeared to be outstanding in respect to flood protection. The report stated that the chief benefit would accrue to communities in the Pemigewasset Valley, but that there would be a marked effect in the Merrimack below Franklin. The control of the Pemigewasset River would be as effective as that of the Winnipesaukee River, which is relatively free from floods.

The 1935-1936 Biennial Report of the New Hampshire Water Resources Board lists three additional reservoirs suggested primarily for river regulation, but affording flood control benefits. These reservoirs are located at Stillwater, on the East Branch of the Pemigewasset; East Jaffrey on Mountain Brook, a tributary of the Contoocook; and Highland Lake on the North Branch of the Contoocook.

An additional group of five reservoirs was suggested by the District Water Consultant of the National Resources Committee. These are located at West Rumney, on the Baker River, South Alexandria, on the Smith River; Cavendar, on the Contoocook River; Roby, on the Warner River; and Wilton, on the Souhegan River.

Data for all 12 of these reservoirs, and for the five reservoirs studied by the Army Engineers are given below:

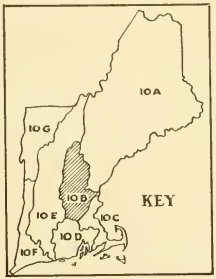
Name	Key	River	Drainage Area Sq. Mi.	Water Surf. Acres	Capacity Acre Feet	Estimated Cost In Dollars
Livermore Falls	A	Pemigewasset	408	6,200	264,000	5,500,000
Blackwater	A	Blackwater	127	4,300	99,000	1,400,000
Suncook Ponds	A	Suncook	55	2,000	39,000	550,000
Water Loom Pond	A	Souhegan	23	550	9,200	190,000
Stillwater	B	Pemigewasset	19	---	5,200	---
East Jaffrey	B	Mountain Brk.	13	450	9,000	---
Highland Lake	B	Contoocook	30	1,500	27,500	---
West Rumney	C	Baker	140	1,700	54,000	2,437,000
South Alexandria	C	Smith	73	2,400	18,500	1,064,000
Cavendar	C	Contoocook	164	2,850	33,000	1,794,000
Roby	C	Warner	88	900	38,500	2,666,000
Wilton	C	Souhegan	65	1,100	48,000	2,531,000
Franklin Falls	D	Pemigewasset	1000	2,950	170,000)	8,680,000
Blackwater	D	Blackwater	125	3,140	46,000)	
Allenstown	D	Suncook	246	3,260	73,400	---
Milford	D	Souhegan	165	3,290	42,170	---
Hillsborough	D	Contoocook	351	4,500	124,000	---

A. Private Engineers group; revised data from N.H.Water Resources Board.
B. N. H. Water Resources Board.
C. District Water Consultant, National Resources Committee.
D. U. S. Army Engineers; included also in list of N. H. Water Resources Board.

Acting under authorization of the Flood Control Act of 1936, the U. S. Army Engineers are engaged in an extensive investigation of the Merrimack Basin for the purpose of making recommendations for a flood control system. The Act authorized a system of flood control reservoirs at an estimated construction cost of $7,725,000, with land and damage costs estimated at $3,500,000.

The field work of the Engineers included a preliminary study of 64 reservoir sites; an aerial survey of a river strip two hundred miles long, and of forty-seven possible reservoir sites; detailed topographic mapping of eighteen reservoir sites; and geological reconnaissance at fifty dam sites, at fifteen of which test pits and borings were made. In all cases the sites selected by the Army Engineers for flood control have been studied by them for additional conservation storage possibilities.

MAP Nº 10B



Legend

H-C HEADWATERS CONTROL

I INVESTIGATION OR STUDY PROJECT

D DRAINAGE

NATIONAL FOREST PROJECT

FLOOD CONTROL RESERVOIR

NOTE: PROJECT NOT MAPPED WOULD PROVIDE NEW STATIONS TO COLLECT HYDROLOGIC DATA.

NEW ENGLAND WATER RESOURCES

RECOMMENDED PROJECTS

EXCEPT WATER SUPPLY AND POLLUTION PROJECTS

MERRIMACK BASIN

DEC. 1, 1937

SCALE

0 5 0 5 10

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

The Army Engineers' initial plan provides for two reservoirs, located at Franklin Falls on the Pemigewasset River and at Webster on the Blackwater River. The Franklin Falls reservoir will control an area of approximately 1,000 square miles and will have a storage capacity of 170,000 acre-feet, equivalent to 3.19 inches of runoff from the drainage area. The estimated total cost of this reservoir is $7,720,000 consisting of the construction cost of $5,942,000 to be borne by the Federal Government, and $1,778,000 for damages, highway, communication and power line relocations to be borne by the states. The Blackwater reservoir will have a drainage area of 125 square miles and a storage capacity of 46,000 acre-feet, equivalent to 6.9 inches of runoff. The total estimated cost is $960,000, of which the Federal Government's share is $580,000 for construction, the remaining $380,000, covering land damages and relocations cost, to be borne by the states. The plans for this site allow for the enlargement of the reservoir to provide combined flood control and conservation storage. The enlarged reservoir would have a storage capacity of 101,000 acre-feet, equivalent to 15.2 inches of runoff from the drainage area. The estimated ultimate cost of this larger reservoir, exclusive of the cost of any power installation at the site, is $1,953,000, of which $1,493,000 is construction cost and $460,000 is the cost of damages and relocations.

Although these reservoirs would be developed primarily for flood control, they would provide incidental benefits to downstream power plants if operated to increase the low water flow.

These two reservoirs would control a combined drainage area of 1,125 square miles, or 22½% of the Merrimack watershed, and would reduce the flood height at Lowell, below the dam, approximately 3.5 feet; at Lawrence, below the dam, 3.6 feet; and at Haverhill, 3.3 feet.

These two reservoirs have been accepted by the Interstate Compact Commissions of the Commonwealth of Massachusetts and the State of New Hampshire, and a compact between these two states is before the U. S. Congress for ratification*. Under the compact, each signatory state is obligated to pay 50% of the cost of acquisition of land, easements and rights-of-way.

Other reservoirs being considered by the Army Engineers to complete the reservoir system are located at Allenstown, Hillsborough, and Milford, — all in the state of New Hampshire. These reservoirs, together with Blackwater and Franklin Falls, would control a drainage area of 1887 square miles, and, it is estimated, would reduce the flood height at Lowell, below the Pawtucket Dam, 6.1 feet; at Lawrence, below the dam 6.9 feet; and at Haverhill, 5.8 feet.

Power Water power developments in the Merrimack River basin were well established by the middle of the nineteenth century. There are

* Compact ratified by New Hampshire and Massachusetts, and signed by Interstate Compact Commissions on July 6, 1937.

now scattered along the main river and its tributaries about 130 plants, with a total capacity of more than 200,000 horse power. At many plants, where power equipment is now obsolete, redevelopment would facilitate efficiency and greater output.

Of the developed water power in the basin, 61½% of the total capacity is within the state of New Hampshire and 38½% within the state of Massachusetts. The capacity of the developments on the main river (Merrimack and Pemigewasset) amounts to about 64% of the total within the basin.

As of January 1, 1937, the Boston District Office of the Water Resources Branch, U. S. Geological Survey, has prepared an inventory of the existing water power developments on the Merrimack. Detailed information regarding individual plants is on file in the Boston office of the Survey. Details on power developments in New Hampshire are contained in the First Biennial Report of the New Hampshire Water Resources Board.

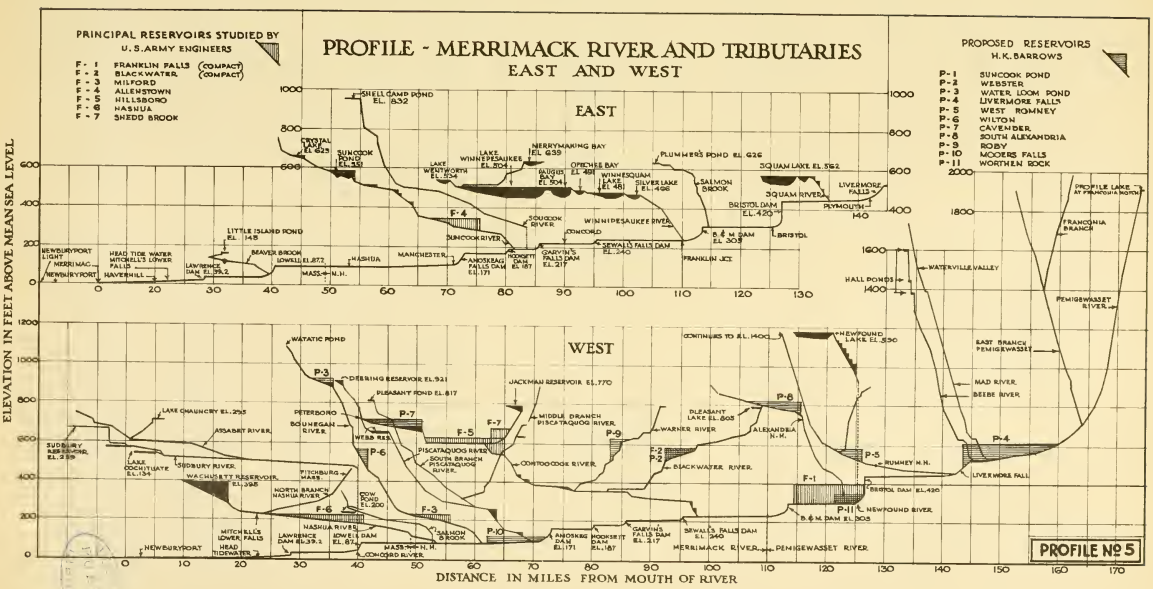
Textile manufactures predominate in the valley. Until recently water power was employed directly by the manufacturing plants for mechanical operations; today, electrical conversion is found better adaptable to efficient production. The largest developments are located on the main river at Manchester, New Hampshire, and at Lowell and Lawrence, Massachusetts.

Most of the desirable sites on the main river have already been occupied; however, some head on the main river and considerably more on the tributaries is still available, and awaits economic justification for development. Heads of 119 and 200 feet respectively could be developed at Livermore Falls on the Pemigewasset River, and at Webster on the Blackwater. An additional 40 feet could be developed on the Pemigewasset and 59 feet on the Contoocook River. Only 25 feet remain for development on the main river.

Establishment of storage reservoirs on the tributaries to provide increased flow during dry periods would benefit both existing and possible future power developments. The present storage of 400 acre-feet per square mile of drainage area raises the minimum flow to about 70% of the yearly mean on the tributaries. It has been suggested that the level of these natural storage basins be raised to obtained additional storage; but, considering the control already effective, it would seem better to obtain artificial regulation on the main river and on such tributaries as do not have natural storage.

The adequacy of electrical energy now generated and the difficulties of competition with modern steam power have tended to stand in the way of the development of water power as a valuable resource. Effective conservation of natural resources requires that it be given due consideration in New England.

More than half of the total fall in the main stream between Woodstock, New Hampshire and tidewater has been developed. (See profile #5). About 57% of the remaining gross undeveloped head could be utilized by power developments at Livermore Falls, Worthen Rock (between Franklin


PRINCIPAL RESERVOIRS STUDIED BY U.S. ARMY ENGINEERS
F-1 FRANKLIN FALLS (COMPACT)
F-2 BLACKWATER (COMPACT)
F-3 MILFORD
F-4 ALLENSTOWN
F-5 HILLSBORO
F-6 NASHUA
F-7 SHEDD BROOK
PROFILE - MERRIMACK RIVER AND TRIBUTARIES
EAST AND WEST
PROPOSED RESERVOIRS H.K. BARROWS
P-1 SUNCOOK POND
P-2 WEBSTER
P-3 WATER LOOM POND
P-4 LIVERMORE FALLS
P-5 WEST ROMNEY
P-6 WILTON
P-7 CAVENDER
P-8 SOUTH ALEXANDRIA
P-9 ROBY
P-10 MOORES FALLS
P-11 WORTHEN ROCK
EAST
WEST
SHELL CAMP POND EL. 632
SUNCOOK POND EL. 451
LAKE WINNIPESAUKEE EL. 504
MERRYMAKING BAY EL. 639
OPECHEE BAY
PLUMMER'S POND EL. 626
SQUAM LAKE EL. 532
SQUAM RIVER
LIVERMORE FALLS
PROFILE LAKE AT FRANCONIA NOTCH
FRANCONIA BRANCH
WATERVILLE VALLEY
HALL PONDS
PEMIGEWASSET RIVER
EAST BRANCH PEMIGEWASSET
MAD RIVER
BEEBE RIVER
LIVERMORE FALL
RUMNEY N.H.
ALEXANDRIA N.H.
PLEASANT LAKE EL. 803
WARNER RIVER
BLACKWATER RIVER
NEWFOUND LAKE EL. 390
CONTINUES TO EL. 1400
NEWFOUND RIVER
BRISTOL DAM EL. 420
B & M DAM EL. 303
PEMIGEWASSET RIVER
MERRIMACK RIVER
SEWALLS FALLS DAM EL. 240
GARVIN'S FALLS DAM EL. 217
AMOSKEAG FALLS DAM EL. 171
HOOKSETT DAM EL. 187
MANCHESTER
CONCORD
SUNCOOK RIVER
TOUSCOOK RIVER
WINNIPESAUKEE RIVER
SALMON BROOK
SILVER LAKE EL. 496
WINNISQUAM LAKE EL. 481
BAGLEY'S BAY EL. 504
LAKE WENTWORTH EL. 534
TROUT POND EL. 625
LITTLE ISLAND POND EL. 148
BEAVER BROOK
LOWELL EL. 877
NASHUA
LAWRENCE DAM EL. 39.2
HEAD TIDE WATER MITCHELL'S LOWER FALLS
HAVERHILL
NEWBURYPORT
NEWBURYPORT HARBOR LIGHT
MERRIMAC
WATATIC POND
DEERING RESERVOIR EL. 921
PLEASANT POND EL. 817
JACKMAN RESERVOIR EL. 770
MIDDLE BRANCH PISCATAQUOG RIVER
PISCATAQUOG RIVER
SOUTH BRANCH PISCATAQUOG RIVER
CONTOOCOOK RIVER
PETERBORO
SCUNEGAN RIVER
WEBB RES.
LAKE CHAUNCY EL. 295
ASSABET RIVER
SUDBURY RESERVOIR EL. 259
LAKE COCHITUATE EL. 134
SUDBURY RIVER
WACHUSETT RESERVOIR EL. 395
FITCHBURG WARE
NORTH BRANCH NASHUA RIVER
COW POND EL. 200
SALMON BROOK
NASHUA RIVER
CONCORD RIVER
MASS. N.H.
MITCHELL'S LOWER FALLS
HEAD TIDEWATER
LAWRENCE DAM EL. 39.1
LOWELL DAM EL. 87.4
P-1
P-2
P-3
P-4
P-5
P-6
P-7
P-8
P-9
P-10
P-11
F-1
F-2
F-3
F-4
F-5
F-6
F-7
PROFILE No 5
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DISTANCE IN MILES FROM MOUTH OF RIVER

Falls and the Ayres Island Development) and Moores Falls. The Worthen Rock development would be absorbed in the flood control reservoir at Franklin Falls recommended by the U. S. Engineers.

There are several thousand feet of undeveloped head in main tributaries of the Merrimack River. Much of this fall, when developed, would have no storage back of it; hence its development would be impractical unless changing conditions in the future made run-of-the-river plants economically feasible. To take a complete inventory of these possibilities would require extensive field and office investigations beyond the scope of this report.

Several of the more outstanding sites have been the subject of examination and reports. Noteworthy among these are the enlarged power and storage developments on the Pemigewasset River at Livermore Falls, and on the Blackwater River near Webster. In addition, developments at sites on the Contoocook, Baker, Smith, Warner, Suncook, Southegan and Piscataquog rivers appear to be feasible.

The chief undeveloped sites are as follows:-

River	Location	Head (feet)	Power Storage (acre-feet)
Pemigewasset	Livermore Falls	119*	264,000
Blackwater	Webster	200	98,000
Pemigewasset	Worthen Rock	40	----
Merrimack	Moores Falls	25	---

*37 feet of head at present developed

Depending on the use to which they were put, these four developments would provide a block of power of from 50,000 to 70,000 horse power. Regardless of whether the energy could be profitably absorbed from plants located at these sites there would be available, depending on the utilization affected, from 100,000,000 to 160,000,000 kilowatt-hours of electrical energy in the average year.

Due to the potential storage for power purposes at the first two sites, there would be available from head at plants already developed downstream on the Pemigewasset, Merrimack and Contoocook rivers an additional yearly output of about 60,000,000 kilowatt-hours.

To make these developments economically feasible there would be required a return of from 5 to 7 mills at switchboard per kilowatt-hour generated. On the basis of preliminary estimates their construction would cost in the neighborhood of $13,000,000, exclusive of transmission costs.

In the studies and investigations for flood control purposes the Army Engineers have found incidental energy increase at existing downstream plants. To ascertain the amount of this increase they have assumed an operating regulation of the reservoirs to augment low flows in the river without decreasing their effectiveness for flood control.

For the Franklin Falls and Blackwater reservoirs the estimated increase would be about 16,300,000 kilowatt-hours. If there were reservoirs also at Milford, Allenstown, and Hillsborough there would be at the existing downstream plants a total yearly increase of energy of about 27,000,000 kilowatt-hours.

The flood control reservoirs studied by the Army Engineers are considered more comprehensively in the Flood Control section of this report.

Navigation The river has been made navigable in the tidal portion, between its mouth at Newburyport Harbor and the railroad bridge at Haverhill, a distance of 20 miles, by dredging a channel 7 feet deep at mean low water and 150 feet wide. The mean range in tide is 7.9 feet at the mouth, and 4.6 feet at Haverhill.

Jetties have been built at the mouth of the river to restrict and direct the flow of water for the purpose of scouring out the bar. To a certain extent this has been effective, but the bar still forms just beyond the jetties. Maintenance dredging by government plant to obtain a channel through the bar is now being carried on.

Serious shoaling having been caused by the flood of March 1936, dredging to restore the project depths of 7 feet below mean low water between Newburyport and Haverhill and of 9 feet just below the wharves at Newburyport is proposed for 1938.

Navigation above Haverhill is restricted to small pleasure craft. Above the dams at Lawrence and Lowell the pools formed by the dams are utilized by these pleasure craft. Canals and locks for navigation around the dams exist at both Lawrence and Lowell, but the canals are so restricted by low headroom under the bridges that no practical use is made of them.

The water-borne commerce comprises chiefly coal and petroleum products. Coal traffic has greatly decreased in recent years, due in part to the shallow channel, but largely to the competition of motor transportation and the increased use of fuel oil.

In the 1935 annual report of the Chief of Engineers the total net registered tonnage in Newburyport Harbor was estimated at 22,384 for the year 1934; similar tonnage in Merrimack River was estimated at 52,578 tons.

In 1914-15 investigation and survey to determine the cost of a channel 18 feet deep and 200 feet wide from the mouth to Hunt's Falls at Lowell, about 2 miles below Pawtucket Dam, was made under Congressional authorization requested by local interests. The cost of enlarging the channel was estimated at $7,076,000, or at $10,000,000 if the construction were to include changes to bridges, power plants and other works of a similar nature. The Chief of Engineers recommended the improvement provided that state and local interests assumed one-half the cost. No subsequent action has been taken by the local interests.

Later, in 1928, the Army Engineers prepared a revised estimate of the cost of improvement as far as Lowell; the total amount was $12,152,100 exclusive of the cost of changes to bridges, power plants and similar items. The estimated annual maintenance cost amounted to $200,000. In this report, the Chief of Engineers gave an adverse recommendation because in his opinion the benefits would not be commensurate with the expenditures.

The 1915 investigation included consideration of an extension from Lowell, Massachusetts, to Manchester, New Hampshire, a distance of 35 miles. The findings of the Army Engineers led them to conclude that the extension was impractical in view of the excessive cost and small amount of commerce which would be benefited.

Since these reports were submitted, industrial activities in the manufacturing centers have suffered a marked decline. This situation, together with the fact that the port of Boston is located within 30 miles of the center of the district, with excellent railroad and trucking facilities available, makes extension of navigation facilities in the Merrimack River unwarranted at present.

Coastal fishing and pleasure boating would be facilitated by a canal parallel to the shoreline between Hampton Harbor, north of the Merrimack's outlet, and the Essex River, on the south. This waterway would offer a splendid safe passage for all types of small craft along 25 miles of the Massachusetts north shore and the New Hampshire south shore. Channeling and other improvement along approximately 12 miles of marsh and tidal bays would provide this inland passage at an estimated cost of less than $2,000,000.

Erosion The reconnaissance survey of the Soil Conservation Service indicates that the problems of soil erosion in the Merrimack valley are neither acute nor widespread. However, uncontrolled erosion invariably increases the costs of channel maintenance and reduces the usefulness of dams and reservoirs because silt inevitably accumulates. An area exceeding 200 square miles along the stream banks from Concord, New Hampshire, to Lowell is already marked by occasional gullies caused, in part, by slight sheet and wind erosion. Another large area subject to erosion extends into the White Mountain foothills along the Baker and Pemigewasset rivers from their confluence at Plymouth. Moderate sheet erosion exists on the Winnipesaukee and Soucook tributaries, while stream bank erosion, although not severe, occurs sporadically in the upper and central portions of the watershed.

In any case sheet erosion tends to become serious because of its cumulative action. The only corrective measures needed in the Merrimack valley are those which automatically accompany such improved farm practices as selective cutting of woodlands, restriction of grazing, and contour plowing.

Drainage In general, the rolling hills of the Merrimack valley are well drained, but in the lowlands near lake, stream, or ocean waters are to be found large tracts of swamp land. Here mosquitoes breed in abundance, and when such breeding places are within the insects' normal flight range of population centers the resultant condition is obnoxious. Corrective measures, particularly drainage, are badly needed in Middlesex County, Massachusetts.

Recreation Variation in topography and density of settlement divides the Merrimack basin into two areas, each with its own types of recreational problems. The mountains, lakes, and hills of the headwaters present a situation different from that in the industrial section of the basin along the main stream and throughout the southern portion of the valley.

In the headwater sections of the Merrimack, commercial recreation has grasped many opportunities to develop the famous mountain and lake summer playgrounds. It is essential that the scenic values inherent in the streams, lakes, and ponds be preserved, since these visual water resources are often the keystone of recreational appeal. Moreover, the sanitary condition of water bodies must not be permitted to threaten the health or the pleasure of vacationist, tourist, or juvenile camper. The use of many tributary streams as refuse carriers gives rise to a problem of balances wherein it is necessary to evaluate the recreational losses so incurred.

The industrial districts in the central and southern portions of the valley need additional recreational facilities. Over much of its course the condition of the Merrimack renders its use for recreation impossible. This condition must be improved; otherwise, pleasure outlets must be found on tributary water bodies. In the tidal portion of the Merrimack the volume of domestic wastes often produces a scum which precludes pleasure boating.

Shellfish on the tidewater flats at the mouth of the river have been affected by river pollution, two-thirds of which may be attributed to local communities and one-third to settlements farther upstream. So long as the river carries a heavy load of wastes, opportunities to increase the fish and game population are confined to the tributaries and to the more northerly portion of the Merrimack. Unless attention is continuously given to their protection and increase, the depletion of these game resources will continue to the point of extinction.

TABLE III-B

SUMMARY OF STREAM FLOW RECORDS - MERRIMACK BASIN

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
Merrimack River at						
Franklin Jct., N.H.	1510	31	73,700	250	2,729	83,000
Garvins Falls, N.H.	2340	9(a)	32,490	301	3,770	122,000
Manchester, N.H.	2850	12	132,000	275	4,303	144,000
Lowell, Mass.	4424	14	161,000	199	6,610	173,000
Lawrence, Mass.	4461	57(b)	159,000	51	6,661	174,000
Pemigewasset River						
East Branch near						
Lincoln, N.H.	104	8	11,200	32	292	17,000
Plymouth, N.H.	622	33	57,300	245	1,357	65,400
Baker River						
Near Rumney, N.H.	143	8	12,600	17.4	238	25,900
Smith River						
Near Bristol, N.H.	84	18	6,890	1.9	300	4,720
Contoocook River						
Nubanusit Brook at						
Peterboro, N.H.	48	11(c)	830	0.4	79	4,140
Near Elmwood, N.H.	168	7(d)	4,500	4	300	4,720
North Branch near						
Antrim, N.H.	54	12	5,570	2.9	92	6,160
Blackwater River near						
Contoocook, N.H.	134	11	13,000	20	216	17,000
at Penacook, N.H.	766	8	46,400	70	1,349	46,800
Blackwater River at						
Webster	129	2	12,600	25	221	17,000
Winnipesaukee River						
Lake Winnepesaukee Out-						
let, Lakeport, N.H.	363	3	27,600 into lake	33	490	27,600
Soubegan River at						
Merrimack, N.H.	171	27	14,200	13	273	16,900
Suncook River at						
North Chichester, N.H.	157	16	11,000	0.4	218	12,900
Nashua River						
So. Branch at Clinton, Mass.	109	40	7,200	9.5	183	11,100

(a) record terminated 1915
(b) record terminated 1934
(c) record terminated 1931
(d) record terminated 1924

SUMMARY OF STREAM FLOW RECORDS - MERRIMACK BASIN

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
Nashua River (cont.)						
East Pepperell, Mass.	433	1	19,450	9.5	830	20,900
No. Branch at No. Leominster, Mass.	107	1	7,530	23.	260	16,300
Concord River						
Lake Cochituate Outlet at Cochituate, Mass.	18	74	248	2.4	26.5	248
Sudbury River						
at Framingham, Mass.	75	62	2,050	0.5	113	2,050

TABLE IV

EXPLANATORY NOTES
Concerning the table of
SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

Column 1. Town or City. Municipalities, arranged alphabetically, where available information positively indicated the existence of an organized sewerage system.
Column 2. Population 1930. Entire population of the civil division as reported by the 1930 Census.
Column 3. Population Served. Best available estimate of the persons served by an organized system.
Column 4. Discharge in thousand gallons per day. The best available estimate of the volume of sewage discharged.
Column 5. Treatment. Abbreviations, noted below, indicate the type of treatment applied to the domestic wastes.
Column 6. Chief sources of Industrial Wastes. The industries which commonly pollute streams are indicated by concise reference to the type of plant, product or raw material.

Symbols

---	No information available
(P)	Partial
(s)	Summer resort.
(S)	State Institution
(U)	College or University
Various	Several industries present with none clearly predominant.
Milk	Refers to pasteurizing, ice cream and dairy plants.
Fert.	Fertilizer factory.
Oil	Petroleum products; storage or distribution plants.
Gas	Illuminating gas manufacturing plant.
Cannery	Includes fish packing.

Im.	Imhoff Tank	A.	Aeration.
Sp.	Septic Tank	Cl.	Chlorination
SF.	Sand filtration.	St.	Settling
F.	Filtration.	Sc.	Screening (fine)
CP.	Cesspool	Br.	Barging sludge to sea.
Sl.	Sludge treatment.	Sm.	Sedimentation
AcSl.	Activated sludge plant.	Ir.	Irrigation

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments

TABLE IV-B

SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

MERRIMACK BASIN

Town or City	Domestic Sewage: Population 1930	Population Served	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Allenstown, N. H.	1,549	1,250	104	none	--
Boscawen	1,359	400	36	none	--
Bristol	1,610	1,200	120	none	--
Concord	25,228	20,000	2,200	none	--
Derry	1,131	500	200	none	--
Franklin	6,576	4,500	304	none	--
Gilford	783	--	--	none	--
Goffstown	3,839	800	72	none	--
Greenville	1,319	500	18	none	--
Henniker	1,266	600	24	none	--
Hillsboro	2,160	600	60	none	--
Hopkinton	1,485	300	--	none	--
Hudson	2,702	600	2	none	--
Jaffrey	2,485	1,000	--	Sp.	--
Laconia	12,471	10,000	350	Sp. Cl. (P)	--
Lincoln	1,548	1,000	90	none	--
Manchester	76,834	57,000	3,705	none	--
Merrimack	1,084	200	--	none	--
Milford	4,068	3,000	180	none	--
Nashua	31,463	24,000	1,750	none	--
New London	812	700	77	Im. SF.	--
Northfield	1,336	800	25	none	--
Pembroke	2,792	1,800	149	none	--
Peterborough	2,521	300	27	Sp.	--
Pittsfield	2,018	600	52	none	--
Plymouth	2,470	1,400	147	none	--
Tilton	1,712	1,200	120	none	--
Warner	1,062	600	15	none	--
Wilton	1,724	800	220	none	--
Wolfeboro	2,358	1,500	16	Sp.	--
Woodstock	756	2,000	--	--	--
	Services				
Amesbury, Massachusetts	11,899	--	--	none	--
Andover	9,969	--	--	none	--
Billerica	5,880	--	306	SF.	--
Chelmsford	7,022	--	233	none	--
Clinton	12,817	1,932	1,469	Sm.SF.	Various
Concord	7,477	751	569	SF.	--
Fitchburg	40,692	--	3,063	Im. F.	Paper & others
Framingham	22,210	3,645	1,309	Im. SF.	--
Haverhill	46,710	--	--	none	--
Hudson	8,469	1,164	627	Sm. SF.	Woolen
Lawrence	85,068	--	--	none	--
Leominster	21,310	--	2,000	none (1)	Plastics & paper

MERRIMACK RIVER BASIN (con't)

Town or City	Pop. 1930	Domestic Sewage: Services	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Lowell, Mass.	100,234	--	5,521	none	--
Marlborough	15,587	--	909	Sm. SF.	--
Maynard	7,156	400	362	Im. F. Sm.	--
Methuen	21,069	--	--	none	--
Natick	13,589	1,685	768	Im. F. Sm.	--
Newburyport	15,084	--	--	none	--
North Andover	6,961	--	--	none	--
Salisbury	2,194	--	--	none	--
Westborough	6,409	613	271	SF.	--

(1) Treatment plant under construction

EXPLANATORY NOTES
concerning tables of the
ORGANIZED WATER SUPPLY SYSTEMS

Column 1. Town or city. Municipalities, arranged alphabetically, where available information indicates the existence of an organized public or semi-public water supply system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 census.

Column 3. Population Served. Best available estimate of the persons served by an organized system (as for the year 1936).

Column 4. Consumption in thousand gallons per day. Best available estimate of the normal daily requirement.

Column 5. Sources of supply. The type of source drawn from is indicated by symbols:- R. for Reservoir, Pond or Lake; W. for Wells, either deep or shallow; Spr. for Spring; Str. for Streams.

Column 6. Watershed area in square miles. Best available estimate of the drainage area upon which the water supply is dependent.

Column 7. Capacity in millions of gallons. Best available estimate of the quantity of water stored by, or immediately available to, the municipal supply.

Column 8. Type of Treatment. Available information concerning the methods used to improve the quality of the water served.

SYMBOLS

(2), etc. Numerals enclosed in parentheses indicate the number of separate water supply systems which serve the municipality. Where there is only one system no symbol is necessary.

(S) Includes State institution
(T) Includes Summer population served
(U) Includes College or School
(s) Provides Summer service only
(a), (b), etc. Letters enclosed in parentheses link civil divisions served by the same water source:-
In column 3 and 4 they link municipalities where available information does not give the number served in each town.
In column 5 letter indicates that the civil division imports water.
In column 6 and 7 letter indicates that the civil division exports water.
Letters link municipalities within one state and basin; cross-references between basins or states appear in footnotes.

Symbols (continued)

A.	Aeration	K.	Activated carbon
Al.	Alum	L.	Lime
AlSl.	Aluminum sulphate	MF.	Mechanical filter
Am.	Ammonia	PF.	Pressure filter
AmSl.	Ammonium sulphate	pH.	Correction of reaction
AS.	Alum - Soda Ash	RF.	Rapid filter
CC.	Corrosive correction	S.	Soda ash
Cl.	Chlorine	SF.	Slow filter
Co.	Coagulation	Sm.	Sedimentation
CuSl.	Copper sulphite	SoCl.	Sodium hypochlorite
F.	Filter	St.	Storage of protective significance.
IR.	Iron removal		

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments
Annual Reports, Public Utilities Commissions

TABLE V-B

ORGANIZED WATER SUPPLY SYSTEMS

MERRIMACK BASIN

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Allenstown, N. H.	1,543	(b)	(b)	(b)	—	—	—
Alton	1,261	700	80	Spr. & W.	—	.05	—
Andover	1,031	320	15	R. & Str.	—	100	—
Antrim	1,254	800	50	R.	.4	33	—
Ashland	1,375	1,000	—	R.	—	—	—
Auburn	735	—	(a)	(a)	—	—	—
Belmont	1,299	600	49	Spr. & Str.	—	.1	Cl.
Bennington (2)	552	430	41	Spr. & Str.	—	.17	—
Boscawen	1,359	—	—	R.	8.9	—	—
Bristol	1,610	1,200	120	R.	96.	9,800	Cl.
Brookline	511	50	1	Spr.	—	.03	—
Campton	1,184	500	12	Spr. & Str.	—	—	—
Concord	25,228	25,000	2,772	R.	3.	685	Cl.
Dublin	506	—	—	R.	—	—	—
Derry	5,131	4,600	166	W.	—	1.19	Cl.
Francestown	363	150	5	Spr.	—	.04	—
Franklin	6,576	6,300	234	Str. & Spr.	—	.5	SF.Cl.
Goffstown	3,839	—	—	Str.	—	—	—
Greenville	1,319	1,250	45	W.	—	.05	Cl.
Hancock	561	250	75	Str.	—	.45	—
Henniker	1,266	1,000	40	Spr. & W.	—	.35	—
Hill	468	300	22	Str.	—	—	Cl.
Hillsborough	2,160	2,000	200	R.	—	.5	—
Hooksett (3)	2,132	—	—	R. & W.	—	.22	—
Hopkinton (2)	1,485	500	75	R.	—	—	—
Hudson	2,702	—	—	W.	—	.05	—
Jaffrey	2,485	2,500	150	Str. & R.	—	.14	—
Laconia (2)	12,471	14,200	530	R.	363.	53,800	Cl.
Lincoln	1,548	—	—	Str.	—	—	—
Manchester	76,834	76,834	5,017(a)	R.	(a)	3,300 (a)	Cl.
Meredith	1,902	1,200	150	R.	—	17	Cl.

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Merrimack, N.H.(2)	1,084	245	13	W. & Spr.	—	.3	A.SF.
Milford	4,068	3,500	212	W.	—	.25	A.SF.
Nashua	31,463	29,000	2,580	W.	—	33.75	Cl.
New Boston	693	—	—	Spr.	—	—	—
New Hampton	692	—	—	Str.	—	—	—
New London,	812	512	55	Str.	3.	33.	Cl.
Pembroke	2,792	2,500(b)	250(b)	R.	3.5(b)	(b)	—
Peterborough	2,521	2,200	200	Str. & R.	—	1.5	Cl.
Pittsfield	2,018	1,500	130	R.	.5	1.7	—
Plymouth	2,470	1,900	200	Spr. & W.	—	2	—
Salem	2,751	1,650	237	R.	2.2	.44	Cl.
Tilton &Northfield	1,712) 1,336)	3,000	303	R.	.8	.2	—
Warner	1,062	600	18	Str.	2.8	4	—
Wilton	1,724	1,000	100	Str.	—	100	Cl.
Wolfeboro	2,358	2,500	300	R.	—	.98	—
Woodstock (2)	756	600	45	Str. & R.	—	1.35	—
Warren	651	—	—	Str.	—	.01	—
		Services					
Acton, Mass.	2,482	568	114	W.	—	—	—
Amesbury	11,899	2,120	640	W.	—	—	IR.A.SF.Sm.Cl.
Andover	9,969	2,502	1,021	R.	2.7	1,038	Cl.
Ashburnham	2,079	—	—	R.	2	400	Cl.
Ashland	2,397	409	210	W.	—	—	none
Ayer (Fort Devens)	3,060	750	212	W.	—	—	none
Bedford	2,603	425	141	W.	—	—	none
Billerica (2)	5,880	1,085	306	W.	—	—	IR.A.Sm.Cl.(P)
Chelmsford (3)	7,022	1,185	233	W. & (a)	—	—	none
Clinton	12,817	2,204	767	R. & (b)	1.7(f)	254(f)	Cl.
Concord	7,477	1,668	654	R. & (c)	1.2	—	none
Dracut	6,912	926	202	W.	—	—	Cl.
Dunstable	384	20	—	W.	—	—	none
Fitchburg	40,692	7,177	4,205	R.	17.8	3,189	none
Framingham	22,210	4,245	1,543	(b)	—	—	Cl.

Town or city	Pop 1930	No. Services	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Groton, Mass.(2)	2,434	532	238	W.	—	—	none
Groveland	2,336	548	70	(d)	—	—	Cl.
Haverhill	48,710	9,094	3,843	R.	17.9(d)	2,933(d)	Cl.
Holden	3,871	674	292	(b) & (e)	—	—	Cl.
Hopkinton	2,563	—	—	W.	—	—	none
Hudson	8,469	1,631	403	R. & Str.	0.8	350	Cl.(P)
Lancaster	2,897	586	109	(f)	—	—	—
Lawrence	85,068	10,516	5,854	Str.	4,461	—	SF.Cl.
Leominster	21,810	3,650	—	Str. & R.	9.5	1,298	Co.Sm.RF.50%;Cl.100%
Littleton	1,447	335	73	W.	—	—	none
Lowell	100,234	16,750	5,521	W.	(a)	(a)	IR.A.Sm.SF.Cl.
Marlborough	15,587	2,883	650	R.	4	750	Cl.
Maynard	7,156	1,487	337	R.	0.7	190	Cl.
Merrimac	2,392	688	190	W.	—	—	none
Methuen	21,069	4,109	1,224	W.	—	—	Cl.
Natick	13,589	3,526	824	W.	—	—	none
Newburyport	15,084	4,200	1,310	R. Spr. & W.	10	250	SF(P)
North Andover	6,961	1,525	562	R.	5.3	4,455	Cl.
Northborough	1,946	—	—	R.	2.4	30	Co.Sm.SF.
Pepperell	2,922	685	248	W.	—	—	—
Salisbury	2,194	845	285	W.	—	—	none
Shirley	2,427	304	77	W.	—	—	none
Southborough	2,166	271	73	(b)	—	—	Cl.
Sterling	1,502	48	—	W.	—	—	none
Townsend	1,752	—	—	W.	—	—	none
Wayland	2,937	918	294	W.	—	—	none
Westborough	6,409	883	—	R.	1.7	45	F.
West Boylston	2,114	—	—	(g)	—	—	none
Westford	3,600	459	166	W.	—	—	none
Westminster	1,925	50	—	Spr.	—	—	none

(b) Boston Metropolitan Water Supply. (See Massachusetts Coastal Basin)
(c) Lincoln (See Massachusetts Coastal Basin)
(e) Rutland (See Connecticut Basin)
(g) Worcester (See Blackstone Basin)

TABLE VI-B

EXISTING WATER POWER - MERRIMACK BASIN

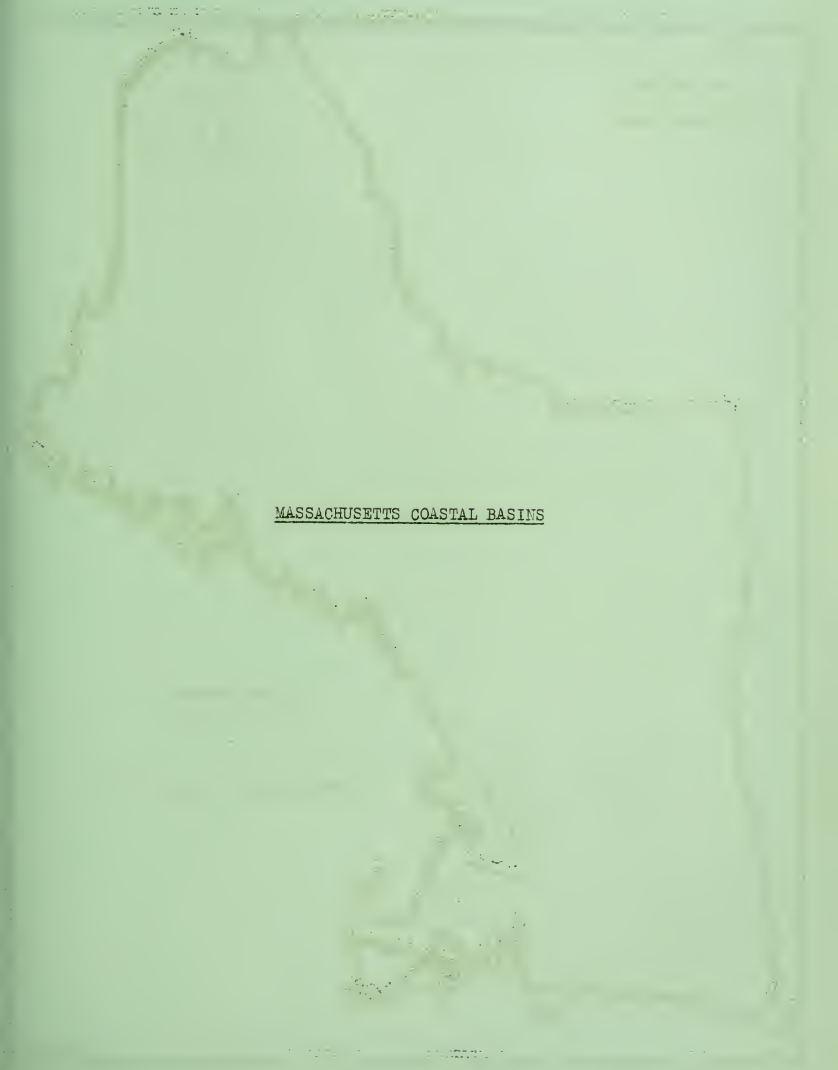
RIVER	NO. OF PLANTS IN		CAPACITY OF PLANTS OF			CAPACITY USED FOR		TOTAL CAPACITY
	N.H.	Ms.	over 10,000 HP.	1,000 to 9,990 HP.	under 1,000 HP.	Utility	Mfg.	Horse-power
MERRIMACK	85	42	109,260	54,883	30,156	65,792	128,507	194,299
Main Stream	4	3	96,060	8,400	0	19,630	84,830	104,460
Pemigewasset	12	0	13,200	6,300	2,635	16,975	5,160	22,135
Winnepesaukee	18	0	0	2,560	4,420	2,960	4,020	6,980
Contoocook	29	0	0	7,250	8,504	6,975	8,779	15,754
Suncook	6	0	0	2,785	1,635	0	4,420	4,420
Piscataquog	4	0	0	8,850	335	8,850	335	9,185
Souhegan	7	0	0	0	2,755	665	2,090	2,755
Nashua	1	5	0	14,918	617	5,417	10,118	15,535
N. Branch	0	18	0	0	4,030	500	3,530	4,030
Concord	0	9	0	1,650	1,950	1,650	1,950	3,600
Others	4	7	0	2,170	3,275	2,170	3,275	5,445

TABLE VII-B: EXISTING STORAGE

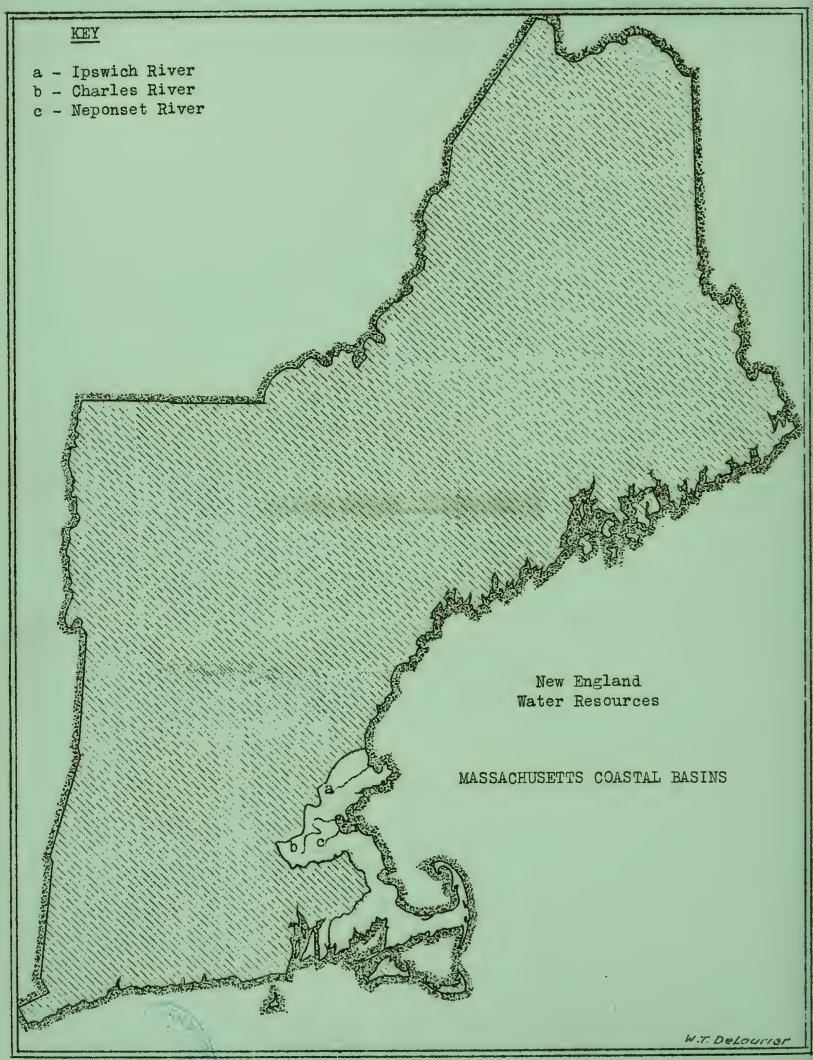
MERRIMACK BASIN

	Drainage Area Sq.Mi.	Water Surface Sq.Mi.	Storage Capacity Acre-feet	Storage Equivalent Inches of Runoff
Squam Lake	58	1.45	45,800	14.8
Newfound Lake	91	8.0	27,500	5.7
L. Wentworth (Smith Pond)	37	4.2	16,000	
Merrymeeting Lake	13	1.8	18,300	
Lake Winnipesaukee	313	72.0	160,300	11.7
Lake Winnisquam	63	6.0	6,900	2.1
Estimated Total	5,000		307,000	1.15
Massabesic Lake (W.S.)		3.9	73,000	
Wachusett Reservoir (W.S.)	118	6.5	199,200	
Sudbury River Reservoirs (W.S.)	92.8	5.9	43,500	
Estimated Grand Total	5,000	183	630,000	2.4

NOTE: Storage equivalent, in inches of runoff, is computed on a basis of all storage above point in question.



MASSACHUSETTS COASTAL BASINS


KEY
a - Ipswich River
b - Charles River
c - Neponset River
New England
Water Resources
MASSACHUSETTS COASTAL BASINS
a
b
c
W.T. DeLourier

MASSACHUSETTS COASTAL BASINS

GENERAL DESCRIPTION

The Massachusetts Coastal Basins, comprising that portion of Massachusetts which drains into Massachusetts Bay on the east, and into Buzzards Bay on the south, has an area of about 1900 square miles, roughly 30% of the area of Massachusetts. It has an ocean front of about 1,000 miles and extends inland for a maximum distance of about thirty miles, averaging between 10 and 20 miles.

The area lies in a coastal lowland, with low undulating hills in the northern and western parts and many lenticular hills, ranging between 100 and 200 feet in altitude, in the central portion surrounding the Boston Metropolitan area. To the south of Boston the topography is gently rolling, with occasional flat areas. The watershed lines between the several small sub-basins, as well as the adjoining basins of the Merrimack and Taunton rivers, are not clearly defined. Many areas in the region contain swampy or poorly drained land. The bedrock formation is principally granite, which appears in outcrops at the surface. In general this bedrock is covered by glacial deposits of gravel and sand. Although not an agricultural area, the deposits of sandy loams, chiefly in flat bottom lands, provide much fertile soil which is used for extensive truck farming and also for subsistence farming.

This section of Massachusetts is the most heavily populated and industrialized in New England; nearly a third of its total area is classified as urban. Almost the entire coastline is developed for recreation, though most of it is privately controlled. The rural parts of the basin are mostly farm land, and nearly 50% of the entire basin may be classed as woodland, a large proportion of which has been burned over and cut over so often that the timber is of no commercial value other than for fuel. On Cape Cod, where the soil is largely sandy, there is extensive scrub growth of pine and oak.

The average annual rainfall in the basin is about 42 inches, ranging from 39 inches at Provincetown, at the outer end of Cape Cod, to nearly 47 inches at Blue Hill Observatory, immediately south of Boston. The temperature averages about 68° in summer and 28° in winter, with somewhat cooler summers and milder winters on Cape Cod and the islands along the shore than elsewhere in the basin.

About a dozen small streams drain into the ocean, the most important of which are the Ipswich, Charles, and Neponset rivers.

The Ipswich River rises in Burlington, in Middlesex County, about 15 miles north of Boston, and flows generally northeast through low agricultural and residential land to the Atlantic Ocean, which it enters at Ipswich, just north of Cape Ann. Its drainage area is about 150 square miles; its length, about 32 miles. The watershed contains many small lakes and ponds, as well as numerous marshy meadows along much of its course. In general the basin is flat, with no hills rising higher than 400 feet. There is little fall in the river, and the flow is normally sluggish.

The Charles River rises in the town of Hopkinton, about 25 miles southwest of Boston and a short distance north of the Rhode Island state line. It follows an extremely meandering course for about 65 miles, although the air-line distance from its source to the lower dam at Watertown is only about 20 miles. From Watertown to Boston Harbor, a distance of 8½ miles, the river was formerly tidal; however, a dam at the mouth of the river now maintains a constant water level in what is known locally as the "Charles River Basin".

The drainage area above the lower dam in Watertown is about 270 square miles. Flow equivalent to that from about 68 square miles is diverted from the Charles River basin into the Neponset River basin through a canal to Mother Brook, a tributary of the Neponset. This diversion dates back to 1798 when rights were granted to the proprietors of mills on Mother Brook, in Dedham, to use one-third of the flow of the Charles River above the point of diversion, located in Dedham.

The basin is from 7 to 10 miles wide in the lower portion, narrowing to 5 miles in the central part and broadening to a maximum of 15 miles toward the headwaters. There are few high elevations in the basin, the hills seldom rising more than 300 to 400 feet above sea level and none so high as 600 feet. There are numerous ponds in the watershed, none of which is large.

The Neponset River rises in Neponset Reservoir, in the town of Foxboro, and flows in a northerly and northeasterly direction to Dorchester Bay, an arm of Boston Harbor. It has a length of about 24 miles and drains an area of about 115 square miles. By reason of the diversion of flow from the Charles River into Mother Brook, an additional 68 square miles should be included in the Neponset drainage area, making the total area about 183 square miles.

The watershed contains a number of ponds and reservoirs, as well as a large amount of swamp-land. The largest swamp area, known as the Fowl or Great Meadows, covers about 3662 acres. Much of this marsh-land has been reclaimed by the State Department of Health.

Discharge records have been kept for about six years by the U. S. Geological Survey, in cooperation with the State of Massachusetts, at a gaging station near Ipswich, on the Ipswich River, and at Waltham, on the Charles River. Records at both stations are too short to afford adequate bases for close determination of the average annual yield of the basins; such records as are available indicate that the annual runoff from the Ipswich basin is about 1.65 cubic feet per second per square mile, and from the Charles basin, about 3.44 cubic feet per second per square mile. Records of the flow of Mother Brook at Dedham, Massachusetts, kept for the past 5 years, show an average discharge of 90.4 cubic feet per second. The figures in Table III-C are summarized from unpublished records of the U. S. Geological Survey at Boston, Massachusetts, and from the Survey's Water Supply Papers covering Part I - North Atlantic Slope Basins.

HUMAN OCCUPANCY

Population This region, comprising nearly 30% of the area of Massachusetts, had a population, in 1930, of 2,416,000. By 1935 this number had increased to 2,485,000, almost three-fifths of the total state population. Fully 90% of the population is classed as urban.

About one half of the total area and nearly 95% of the total population are in metropolitan districts, as defined by the U. S. Bureau of the Census; specifically, the basin includes most of the Boston Metropolitan District and small portions of the Lowell-Lawrence and Providence-Fall River-New Bedford Districts. The remaining territory consists of small towns and rural areas.

The region has a high population density, 1,070 persons per square mile, or double the density for the state.

Metropolitan Boston, containing 2,384,465 people in 1935, is a thickly settled urban and suburban district. It includes in addition to many smaller communities four cities of more than 100,000 population: Boston, 817,713, Cambridge, 118,075, Lynn, 100,909, and Somerville, 100,773. Outside Metropolitan Boston, New Bedford (pop., 110,022) is the only city of over 100,000. The numbers of cities and towns in the basins, in various population groups as of 1935 are:

	Number
Over 100,000	5
25,000 to 100,000	13
10,000 to 25,000	26
5,000 to 10,000	18
2,500 to 5,000	21

Eastern Massachusetts, with the exception of some towns outside of the metropolitan districts, has gained consistently in population, although at a diminishing rate, since 1900, and more rapidly than the state as a whole. The relative growth of communities between 1920 and 1930 is shown on Map 7. Comparative rates of increase of population areas were:

Period	State	Mass. Coastal Basins	Metropolitan Boston
1930-1935	2.4%	2.9%	3.3%
1920-1930	10.4%	11.5%	14.9%

Judging by the diminishing rate of growth of the entire state and by past trends in various areas within the state, it is evident that increase in the population of the Massachusetts Coastal basins will not continue at so high a rate as in the past. Based on the state population in 1935 of 4,351,000, a predicted estimate by competent authorities is 4,623,000 for 1960, an increase of 275,000 in twenty-five years, or less than 3% per decade. On account of the concentration in this eastern section its relative increase will undoubtedly be greater than that in other parts of the state, and the major portion of the new population will probably be located in the metropolitan districts.

Agriculture The rural population of the basin is less than one-tenth of the total. In Barnstable county, however, the rural proportion is about two-thirds, and the greater part of this population is in the non-farm class. Nevertheless, farming activities are generally intensive, especially dairying, fruit growing, truck gardening for local markets and, in the Cape Cod section, cranberry cultivation. The cranberry crop yields a substantial revenue and constitutes about two-thirds of the production in the entire country.

A higher rate of increase in the rural non-farm element and a tendency to spread beyond the existing suburban limits are in evidence as results of the widespread use of the automobile. In the thickly-settled areas the inordinate demand for farm products will probably encourage the establishment of more small poultry and truck farms; however, no significant changes in the types of farming activity are anticipated.

Industry The northern portion of this region is highly industrialized. In the southern part the only large industrial center is New Bedford - the leading city of New England in the production of fine cotton fabrics. Cape Cod, primarily a recreation region, has practically no manufacturing. The basin as a whole contains a wide variety of manufacturing interests and accounts for about fifty percent of the value of products manufactured in Massachusetts.

The decrease in industrial activity in the manufacturing cities of this area between 1927 and 1933 was approximately the same as the average decrease in the United States as a whole, although some centers, such as Lynn (a shoe city) and New Bedford (a textile city), lost slightly more. There is, however, a wide diversity in industries in the metropolitan districts, and in cities of specialized manufacturing efforts are being made to introduce diversified lines to a greater degree. This will undoubtedly tend to stabilize employment and will lead to a more consistent growth in manufacturing.

Mining Granite may be quarried almost anywhere in this region except on Cape Cod and Nantucket and Martha's Vineyard Islands. The quarries at Quincy and Rockport account for a large share of the granite production of Massachusetts, which exceeds that of any other New England state. There are no other minerals quarried or mined on a commercial scale. No change is anticipated in stone production beyond a natural expansion which may possibly accompany increased activity in the construction field.

Lumbering There is practically no lumber production in this part of Massachusetts, and the sale of forest products accounts for only 2% of farm income.

Fishing This region contains, in Boston, the principal fishing port of the United States. Gloucester is the second port in importance. In 1934 the value of the catch brought into these two ports amounted to nearly $8,000,000, about one half of the total value for the six New England states or for the entire Pacific Coast. Provincetown, on Massachusetts Bay, and New Bedford, on Buzzards Bay, are other important bases for commercial fishing. Although most of the fishing is done on

the banks far off the coast, there is in Massachusetts Bay a large amount of shell fishing, which is seriously affected at many points by pollution resulting from the sewage discharged by large metropolitan areas and local communities. Relief from this threat to the fishing industry is essential from both the economic and the health standpoint. Commercial organizations hope to bring about expansion of the fishing industry by broadening its market and increasing the variety of prepared fish products. The best means of accomplishing these ends are now being investigated.

Recreation This basin, where there is the greatest concentration of population in New England, includes one of the most favored recreational areas on the Atlantic seaboard. Metropolitan Boston is the fifth largest metropolitan district in the country, both as to area and population; the North Shore, South Shore, Cape Cod and Buzzards Bay together represent one of the most highly developed recreational regions in the United States.

The publicly-owned land devoted to recreation in the basin is extensive, but the value of the private land developed for the same purpose is probably unequaled in any other one section of equal size in the country. The recreational opportunities of the urban population and the investments of summer residents are both threatened, however, by the extensive pollution along much of the basin's shore.

Extensive areas are closed to shell fishing in the following localities: Newburyport, Ipswich, Rockport, Gloucester, Manchester, Danvers, Beverly, Salem, Marblehead and from Lynn to Winthrop on the North Shore; Boston Harbor, Cohasset, Kingston and Plymouth on the South Shore; Provincetown, Chatham and Barnstable on the Cape; and Wareham, Mattapoisett, Fair Haven, New Bedford and Dartmouth on Buzzards Bay. Pollution has rendered these waters too unhealthy for shellfish; in fact, safety for bathing is dubious.

The shortage of publicly-owned beaches for the use of the millions living in the basin has been widely acknowledged. There are seven state-owned beaches, but, as the Progress Report (1936) of the Massachusetts State Planning Board states, "these shore reservations are far from adequate to serve the existing and potential demands." The report recommends the acquisition of six additional beaches in the basin. Unfortunately, no favorable action has yet been taken by the legislature on this essential program.

The Neponset River is so polluted by industrial waste that its recreational use is hampered. Conditions in the Mystic River are somewhat similar. In the Charles River, which is used extensively for recreation, pollution from sewage and industrial plants exists to a less degree, but additional improvement in its condition is desirable for the greatest utilization of its recreational possibilities.

The concentration of population within the basin necessitates the fullest use of all recreational opportunities. Acquisition of shore areas for bathing and protection of streams and beaches from pollution is essential to any balanced program of recreational development in the basin.

Transportation Water transportation is almost entirely limited to ocean waters. Of several seaports, Boston, one of the principal ports of the country, is the largest. It is being provided with a 40-foot ship channel and has extensive docks and warehouses and several trunk line railroad connections. Its terminal facilities are more than adequate to meet the volume of traffic in the harbor, but channels to docks and wharves need to be improved.

New Bedford, on the southern coast of the region, is the second port of importance; here are a 30-foot channel and ample facilities. Gloucester, Salem, Lynn and Provincetown are minor ports used principally by local coast-wise traffic.

The only inland route of consequence is the Cape Cod Canal connecting Massachusetts Bay with Buzzards Bay, and shortening the route from Boston to New York by about 60 miles. There is one other inland route - a canal across the base of Cape Ann, connecting Gloucester and Annisquam harbors, which is used primarily by fishing and pleasure craft.

The Mystic, Neponset and Weymouth Fore rivers, the tidal portions of which are essentially arms of Boston Harbor, are navigable for only short distances from the harbor; they are, however, commercially important parts of the Port of Boston. The remaining streams of the region have no transportation value.

This region is covered with a vast number of highways and secondary roads. The principal long-distance routes radiate from Boston, and on account of the dense local traffic are seriously congested at many points. The principal need of the region is for trunk routes of modern design for through traffic that will by-pass thickly settled areas. This need is most evident in connection with north and south movements through this section, and with traffic going around Boston.

Eastern Massachusetts is covered with a network of railroad lines, centering at Boston. This network was originally composed of a large number of independent local roads. Upon consolidation into the present systems many of these lines were found to be unprofitable, and the result has been a gradual curtailment and often abandonment of service. However, the remaining lines, together with the bus and truck services which have usually been established to replace any discontinued railroad lines, provide adequate transportation facilities in practically all parts of the region.

Scheduled air transport service is provided from the Boston airport to a majority of the important cities of New England and, through connections at Newark and Albany, to the national airline network. In addition, the trans-Atlantic air service soon to be established may include Boston as a stop on some trips. In the vacation season, scheduled service is provided from Boston and New Bedford to Cape Cod points, Martha's Vineyard and Nantucket. Additional air travel facilities are provided by charter service at the more important airports. While there are numerous landing fields in this area, improvement of many of them is needed to provide adequately for aviation operations.

WATER USE AND CONTROL

Pollution The Boston Metropolitan District, comprising the city of Boston and its suburbs, is served by a system of intercepting and main outfall sewers operated by the city of Boston and by the Metropolitan District Commission. There are three main sewerage systems which discharge their sewage through three long outfall sewers into Boston Harbor, without treatment, other than coarse screening and dilution. This method of disposal is unsatisfactory, and eventually additional treatment will become necessary.

Many of the existing intercepting and trunk sewers, designed many years ago to serve populations materially less than those now tributary to them, are of too limited capacity to handle adequately the present quantities. In many places in the district, relief trunk sewers are needed to reduce the volume of sewage now overflowing into the rivers and tidal estuaries. No adequate plan of construction of relief sewers and appurtenant works has yet been prepared, but before any major construction program is started comprehensive engineering studies should be undertaken.

Similar extensive improvements are needed in the areas outside the Boston main drainage district, principally in the Charles and Mystic River valleys, which, for the greater part, are within the Metropolitan Sewerage District. Legislative reports have been made on many projects designed to relieve overloaded trunk sewers along these river valleys. In the North Metropolitan area, one major relief sewer is now under construction and other similar projects are known to be needed.

In its upper reaches the Charles River receives relatively large amounts of mixed wastes from Franklin and Medway, and incompletely purified sewage from Milford. The effects of these wastes are especially noticeable at these points but, through natural purification, the quality of the water is greatly improved before it reaches the lower end of the river, and is not objectionable in the Charles River Basin. However, occasional storm overflows in the lower portion of the valley contaminate the water.

The Mystic River and its tributaries are also in an unsatisfactory condition due to industrial wastes and sewage overflows. The enlargement and extension of sewers of the North Metropolitan District would aid materially in the abatement of pollution in the Mystic.

The Neponset River, which flows through the South Metropolitan District, is primarily an industrial stream, and analyses of the water show that there is pollution, due largely to color and suspended solids in industrial wastes. However, partial relief in this valley has been effected by the extension of sewers of the South Metropolitan District.

A special Joint Commission was authorized, under a legislative resolve of 1935, to investigate the discharge of sewage into Boston Harbor and its tributaries. The recent report of this Joint Commission stated: "The investigation showed that much of the North Metropolitan Sewerage System is inadequate in capacity to receive the storm water and domestic sewage tributary to this system, and inadequate to receive the domestic sewage and industrial wastes in some parts of the system." In this connection, the Joint Commission recommended the inauguration of a program to remove

storm water from the North Metropolitan Sewerage System, the South Metropolitan Sewerage System and the Boston Main Drainage System. The Commission recommended legislation requiring construction of sewers and appurtenances for preventing storm waters from entering the three systems.

The investigation covered also the matter of the treatment of sewage before its discharge into the harbor. Investigation did not disclose serious pollution in the harbor, except in the vicinity of the three main outfalls, but evidence of pollution was obtained on adjacent shores, where it had been carried by tides and winds. The opinion of the Joint Commission was stated in the report to be that "the condition of Boston Harbor has not reached such a state as to be dangerous to public health, and the Special Commission cannot therefore recommend that treatment works be provided at this time, but is of the opinion that the population residing in the vicinity of Boston Harbor will soon demand a change in spite of the fact that the present conditions are not dangerous to the public health. To meet these demands works for treating the sewage and for disposing of the sludge will have to be provided."

In some of the outlying areas in the Boston Metropolitan District there are towns of considerable size which are without sewerage systems, and the streams and tidal estuaries draining such places are highly polluted. Many of these places lie within a territory which should be served, either by main intercepting sewers of the Boston Metropolitan District or by local sewerage systems and treatment works.

In the area served by the South Essex Sewerage District, there are several ominous pollution abatement problems. The waters of Salem and Beverly harbors are objectionable at times, chiefly because they receive industrial wastes from the Sewerage District outfall sewers and the North and Danvers Rivers. The North River, one of the most polluted streams in New England, receives quantities of industrial wastes, chiefly from tanneries in Salem and Peabody. Plans for eliminating this nuisance have been prepared, and the construction of the necessary facilities should not be delayed. The Danvers River is polluted by industrial wastes and domestic sewage from Danvers, one of the largest communities in Massachusetts without a public sewer system.

With the exception of those communities lying within the Boston and Salem districts, problems of pollution abatement and control must in general be solved by individual communities of the basin. Because these communities are relatively small, conflicting interests, in matters pertaining to the pollution of rivers and coastal waters, are not of serious consequence. Sewer systems and disposal works are needed in many towns, particularly where there are thickly settled village centers. In many cases the immediate requirement is for an engineering study to determine the actual needs and to suggest methods by which waters in the vicinity may be improved and protected against pollution.

Several towns and villages situated along the shores of Cape Cod Bay, Nantucket Sound and Buzzards Bay should be provided with sewerage and sewage disposal works. Plymouth, for example, now discharges sewage through outlets along the shores of Plymouth Harbor, causing offensive conditions in these waters. Sewerage and sewage disposal facilities are needed in Provincetown, Falmouth, Wareham and Mattapoisett. Improvements at Fairhaven are also needed. The many fine beaches and sheltered bays along

NEW ENGLAND WATER RESOURCES

SEWAGE AND POLLUTION

MASSACHUSETTS COASTAL BASINS

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº 1
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the shores of Cape Cod and vicinity have given this section an enviable reputation as a summer playground, but to keep this reputation entails the protection of these waters against contamination which might in any way detract from the recreational advantages offered.

In the vicinity of the larger cities in this basin there has been such a pronounced migration of population from urban areas into suburban communities, especially in summer, that extensions of sewerage facilities have frequently not kept pace with other developments.

Water Supply The chief water supply needs in the Massachusetts Coastal Basin are for the extension of present systems into areas not now served, and for the provision of treatment for surface supplies where the condition of the water is unsatisfactory, usually because the source is in a thickly populated district. Only a few scattered communities have no water supplies. Most of those communities within 10 miles of Boston are served by the Metropolitan Water System which has as its source the Cochituate, Sudbury and Wachusett Reservoirs and the Ware River. The water of this system receives no treatment except for the aeration incidental to storage and except for chlorination, which has been adopted as a precautionary measure.

The Quabbin Reservoir, now under construction in the Swift River Valley, will nearly double the amount of water available and, it is expected, will be adequate to meet the needs of Metropolitan Boston for a good many years. Before this latter source of supply could be constructed the diversion of water from the Swift and Ware river tributaries of the Connecticut was reviewed by the Supreme Court. Their decision was to the effect that since the principal use of water is for domestic water supply the diversion was justified. However, the Court did rule that only those waters in excess of a specified minimum flow could be diverted for use by the Metropolitan Water Supply System.

The Quabbin Reservoir will also be used as a supplemental source for the Worcester Water Supply. When the Quabbin Reservoir is completed and in use it is possible that some parts of the Sudbury Basin, where the water is not of satisfactory quality for domestic supply, may be used for recreational purposes. The by-passing of these areas and of some of the older reservoirs which will be used for standby service only will require an additional aqueduct system from Wachusett Reservoir to Boston.

Within the Metropolitan Boston District there are several towns which are not served by the Metropolitan Water Supply System. Cambridge, the largest of these, has several reservoirs in the Charles River Basin, the water from which is completely purified before use. Newton and Brookline both have independent well supplies, but supplement these sources with water from the Metropolitan System. Waltham has a ground water source, the water from which is so impure that treatment works will be needed in the near future. Winchester, with a surface supply; Woburn, with a well supply; Wakefield, with a combined well and surface supply;and Lynn and Saugus,with a combined surface supply, are the other municipalities within 10 miles of Boston which are not served by the Metropolitan system. Because of the density of population and the resultant likelihood of contamination of water supply sources, these towns are forced to exercise constant supervision over their supply sources and to keep a constant check on the adequacy of purification methods.

In the southern part of the basin New Bedford, with a 1935 population of 110,022, takes its water from Great and Little Quittacas Ponds. As this source is comparatively free from pollution and as the watershed population is sparse, the water is used without treatment. On Cape Cod, communities which do not have public water supply systems include Eastham, Mashpee, Orleans, Sandwich, Truro and Wellfleet. These six towns have a year-round population of 4858 and a much larger population than this in summer. Although there are only a few surface supply sources available in this region, well supplies could easily be developed. The latter type of source is probably the most desirable here as it obviates setting aside for watershed protection areas of distinct recreational value. Most of the towns along the South Shore have public water supply systems. The majority of these supplies are municipally owned; most of them have ground water sources, and many undergo some sort of corrective treatment. The following communities, with a total population of 3041, are the only ones without organized systems: Halifax, Norwell and Plympton.

North of Boston the only communities without organized water supply systems are Boxford, Essex, Hamilton, Newbury and Rowley, with a total year-round population of 7518, although the summer population is appreciably larger. Because of the concentration of population in all of these towns except Boxford, they are in need of municipal systems. Suitable surface supply sources in the vicinity of these towns are probably not available because the topography is so flat and because the region is covered with scattered farms and estates. However, opportunity does exist for the development of small well supplies.

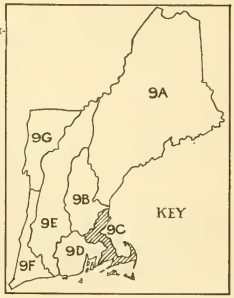
The typhoid death rate in Massachusetts has been very low for many years, probably because the water supply systems have been so well operated and because the treatment of water has been so carefully supervised. If the use of the Metropolitan Water Supply were more nearly universal among the towns in the Boston area, the possibility of water supply contamination would be decreased and the availability of undeveloped lands and water bodies for recreational purposes would be increased in this district where recreational facilities are now so inadequate.

Flood Control No general flood conditions are to be found on these rivers, although possibly there are local stream conditions which might be remedied by dykes and channel enlargements. During freshet seasons the rivers frequently overflow their banks, spreading out over considerable areas of low-lying borderlands. These low areas serve as retention basins, and usually no loss is incurred by flooding. Nor is any great inconvenience caused, aside from that resulting from an occasional blocking off of secondary highways through the low areas. The retention of water in these marshy areas lowers the peaks in the river channel downstream where it passes through more intensively developed sections, with the result that any losses which do occur are minor.

Power Water power developments on the streams in this region are few and of minor importance. The rivers offer little opportunity for power developments on account of their small amounts of fall and their low discharges, especially in summer.

A survey of the water resources of Massachusetts made in 1918 by the Commission on Waterways and Public Lands revealed that on the Neponset River,

MAP Nº 9C



Legend

- △ WELL, ○ SPRING, □ SURFACE } NO TREATMENT
- △ WELL, ⓒ SPRING, [C] SURFACE } TREATED, WITH DISINFECTANT
- ▲ WELL, ◑ SPRING, ◨ SURFACE } TREATED MECHANICALLY
- ▲ WELL, ● SPRING, ■ SURFACE } MECHANICALLY TREATED AND DISINFECTED
- INSIDE SYMBOL OF SUPERIMPOSED SYMBOLS INDICATES TREATMENT OF ALL.
- ◯ SUGGESTED PROJECT
- • SUPPLIED BY THE METROPOLITAN BOSTON SYSTEM

NEW ENGLAND WATER RESOURCES

WATER SUPPLIES
MASSACHUSETTS COASTAL BASINS

DEC. 1, 1937

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT NO 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

SCALE
8 0 8 16

slightly over 200 feet of fall were utilized at the 27 dams along its course. Since the time of that report, many of these privileges have been abandoned. Some 20 ponds and reservoirs in the watershed have a combined water area 2.65% of the basin area. The estimated storage of these bodies of water is 460 million cubic feet.

The Charles River, having 91 feet of fall, utilized at 11 dams; the Ipswich River, with 31 feet of fall, utilized at 4 dams; and the Acushnet, having 32 feet of developed head divided equally among 4 dams, are the only other streams having developments worthy of mention.

Whatever power may be obtained from these rivers is but a small percentage of the total power consumption of the manufacturing plants which use water power. The various privileges have progressively been abandoned as water wheels became obsolete, because it was more costly to make improvements to the plants than to purchase power.

According to information compiled by the U. S. Geological Survey as of January 1, 1937, 2555 horsepower is developed at the 13 installations of over 100 horsepower in this basin. By far the largest single installation is one of 600 horsepower on the Neponset River.

Navigation Two of the three major ports of Massachusetts, Boston and New Bedford, are in this basin. The third, Fall River, is in the Thames-Blackstone-Taunton basin and is described in that section of this report.

The Port of Boston has a harbor area of 47 square miles, which includes all the tidewater lying within a line from Point Allerton, on the south, to Point Shirley, on the north, and a water frontage of 140 miles. A total of seven miles of this frontage is on water 35 or more feet deep. Through the outer harbor there are three main channels 40, 30 and 27 feet deep respectively and each 1000 to 1500 feet wide, navigable throughout the year. The main channel of the inner harbor is 35 feet deep, and 1200 feet wide. There are approximately 1500 acres of anchorage in the harbor. The water-front facilities include 203 wharves, the principal piers having tract connections and facilities for direct transfer of cargo between freight cars and vessels.

The freight traffic entering and leaving this port in 1935, as given in the 1936 Annual Report of the Chief of Engineers, totalled 16,384,958 tons, valued at $581,362,571. The tonnage was slightly more than the ten-year average of 16,200,000 tons, and the value somewhat less than the ten-year average of $755,000,000. Water transportation lines serving this port carried 1,248,755 passengers; in addition there were 8,472,216 ferry passengers.

To improve the facilities of this harbor and provide ample channel accommodation for large transatlantic vessels, the main ship channel is being deepened to 40 feet, under an existing project of the U. S. Army Engineers. Other smaller channels are to be dredged under this same project. Suitable approach channels and berths of 40-feet depth, at certain terminals, are to be provided by the Commonwealth of Massachusetts, in accordance with the requirements of the Rivers and Harbors Act of October 30, 1935. This will include the dredging of 40-foot channels from the Boston & Albany Railroad Piers at East Boston and from Commonwealth Pier #5, South Boston, to the main ship channel.

The Cape Cod Canal between Buzzards Bay and Cape Cod Bay is being increasingly used for coastwise traffic and, since 1928, when the United States acquired ownership of the canal, its use has been nearly doubled. At present, the traffic through the canal amounts to about 20% of the total coastwise traffic between Boston and southern ports. In 1935, the total tonnage through the canal was 2,627,376, valued at $138,409,453; 213,494 passengers were carried through the canal by commercial transportation lines.

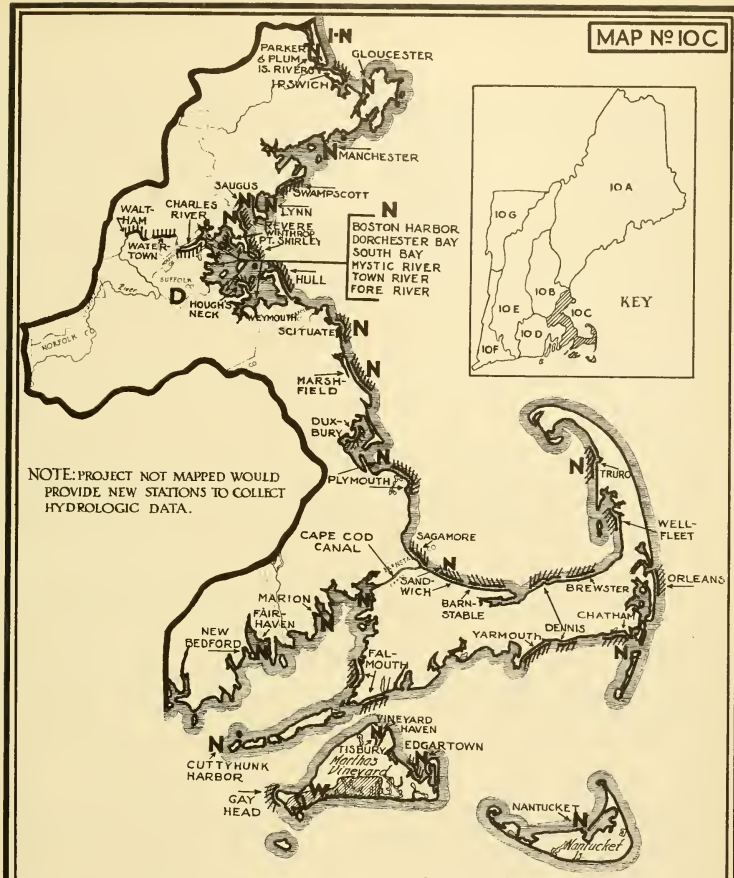
To provide safe passage for the increasing traffic a project to increase the depth of the canal to 32 feet and the width to 500 feet was authorized by Congress, and work on this project has been under way since 1933. It is expected that the deepening of the canal will be completed during the year 1938. It is anticipated that when this improvement has been made twice as much tonnage will pass through the canal. This greater use will materially reduce the annual loss from shipwrecks on the outer shore of Cape Cod, which has averaged over $500,000.

New Bedford Harbor is a tidal estuary on the western side of Buzzards Bay. The outer harbor is two miles wide and three miles long. A channel 30 feet deep and 350 feet wide extends from deep water to above the New Bedford-Fairhaven bridge, a distance of 5⅝ miles, and continues north for ¾ of a mile, at a depth of 23 feet and width of 100 feet. Protected anchorages are available in Buzzards Bay, and the inner harbor has two deep anchorage areas aggregating 94 acres. Waterfront facilities include 27 wharves on the New Bedford side of the harbor and 6 along the Fairhaven side. Freight traffic in 1936 amounted to 681,076 tons, valued at $50,315,256.

Improvements in New Bedford Harbor to provide more nearly adequate navigation facilities have been authorized by Congress, and will involve provision of a deeper channel along the Fairhaven waterfront and enlargement of anchorage or manoeuvering areas in the harbor by removal of several rock ledges uncovered in previous dredging operations.

Other improvements which have been authorized by Congress on recommendation of the Army Engineers are: the completion of dredging of a channel 27 feet deep and 300 feet wide in Weymouth Fore River from Hingham Bay to the river bridge at Quincy Point; the dredging of a channel 15 feet deep, with varying widths in Weymouth Back River; and the deepening of the channel in Lynn Harbor from 22 to 25 feet to enable vessels to load to a greater draft than is now possible; dredging a channel averaging 150 feet in width and 17 feet in depth in Edgartown Harbor, and removing shoals in the anchorage area to a depth of 12 feet; and dredging a channel 10 feet deep and 75 feet wide into Cuttyhunk Harbor with an anchorage of like depth about 16 acres in area inside the harbor.

The completion, during the fiscal year 1937, of the new 8-foot channel in Annisquam River, connecting Gloucester Harbor and Ipswich Bay, will provide an important link in the proposed inland waterway from Gloucester north to Hampton, New Hampshire. Beyond Ipswich Bay a canal can be constructed through inland bays and marshes from Essex River, behind Castle Neck, to Ipswich River; thence, along Plum Island River, through marshes to the Merrimack River; and finally to Hampton Harbor, passing inland from Salisbury Beach. This waterway, connecting the many harbors along the North Shore of Massachusetts, would offer a safe passage for small boats, both pleasure and fishing craft.



Legend

- BEACH AND SHORE PROTECTION
- I INVESTIGATION OR STUDY PROJECT
- N NAVIGATION

NEW ENGLAND WATER RESOURCES

RECOMMENDED PROJECTS

EXCEPT WATER SUPPLY AND POLLUTION PROJECTS

MASSACHUSETTS COASTAL BASINS

DEC. 1, 1937

SCALE

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

Erosion Except on Cape Cod, erosion problems are restricted to comparatively small areas. In the town of Essex, adjoining Gloucester, the Soil Conservation Service has reported that there are approximately three square miles of moderate sheet and severe wind erosion. The islands south of Cape Cod -- Martha's Vineyard, Nantucket and No Mans Land -- have a few areas marked by moderate sheet or very severe wind erosion. Cape Cod, a sandy, arm-shaped peninsula, shows eroded characteristics from Barnstable, at the biceps, to Provincetown at the fist, the degree of erosion varying directly with the distance from the shoulder. Nearly the entire forearm is marred by various degrees of sheet and wind erosion, while the wrist and fist suffer from severe wind erosion. In general, erosion is confined to cropped slopes and to exposed sandy soils, while wood and pasture lands have been damaged but little.

That portion of the shore line of Massachusetts which extends from Boston Harbor to the south differs in character from the shore line to the north. In general, the latter is rocky, but the former is, for the most part, sandy and subject to continuous erosion by waves and wind. Cape Cod is especially vulnerable to the attacks of these forces, and ever since the glacier deposited this long arm of sand nature has been constantly at work modifying its formation. The sandy beach which stretches along the fifty miles of outer shore from Chatham to Provincetown has been washed and blown away toward the tip of the Cape to form its lower end west of Provincetown. This action is so continuous that the outer shore would afford a good laboratory for the study of the erosive action of wind and waves.

A program of investigation, providing for a continuous study under the auspices of the Federal Government's Beach Erosion Board, with the cooperation of state and local agencies, should yield important basic data.

Massachusetts has already spent about $3,000,000 on the protection of its shore line, in constructing sea walls, jetties and other types of protective works. This and further construction is felt to be a proper expenditure for public funds in that it will preserve the beaches for recreational use, increase the taxable value of land, and enable the owners of shore property to develop the land to better advantage.

Drainage Hordes of mosquitoes have bred every year in the extensive salt marsh areas along the coast. The desirability of draining these swamps has long been recognized, but no concerted action was ever taken until 1930, when the Cape Cod towns, under Legislative action, inaugurated projects of mosquito control. This work has been successful in reducing the mosquitoes to 10% of their former numbers.

The definite benefits secured on Cape Cod and Nantucket Island prompted the expansion of drainage activities as a work relief measure. Extensive areas of salt marsh have been drained along the Massachusetts seaboard, until at present the entire coastal area has been largely cleared of salt marsh mosquitoes. Supervision over construction and maintenance of all drainage was placed in the hands of the State Reclamation Board.

The fresh water marshes also are productive of mosquitoes but to less extent than are the salt marshes. Those bordering on the Neponset and Charles

rivers and in the environs of Boston afford conditions for the breeding of mosquitoes. These swamplands may be drained or filled in in order to eliminate mosquito breeding, but in some cases such operations would be costly.

Recreation In spite of the fact that this basin has about a thousand miles of seashore, the proportion that is under public ownership, and hence accessible to the general population, is far from enough to meet popular demand for bathing beaches. Not only must there be acquired for public ownership many additional beaches, but care must be taken that these public beaches are acquired in districts where the water is free from pollution. The public has made manifest such a demand for uncontaminated ocean waters, not only for bathing but also for shell-fishing, that investigations have already been undertaken to determine what steps would be necessary to relieve the polluted condition of coastal waters in the Massachusetts Bay region. Further study of the bathing and shell-fish problems will probably establish the feasibility of treating wastes or of discharging them into the ocean at points where tidal action will not carry pollution to beaches and shellfish areas.

Pleasure boating has long been popular in this region, and this popularity may be definitely enhanced by the provision of additional inland waterways safe for small craft. The North Shore canal proposal, previously mentioned, would foster expansion of pleasure boating. The increased size of the Cape Cod Canal will also be of real benefit to the yachtsman, who has often in the past been denied the privilege of using the Canal because it was used very nearly to capacity by commercial vessels.

Density of settlement results in serious curtailment of the number of water fowl and other wildlife in these coastal and inland waters. Further attention should be directed toward providing local areas sufficiently isolated and protected to prevent extermination of native wildlife and to provide attractive resting spots for migratory fowl.

TABLE III-C

SUMMARY OF STREAM FLOW RECORDS

MASSACHUSETTS COASTAL BASIN

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
Ipswich River near Ipswich, Mass. (Willowdale, Mass.)	122	6	2,490	1.4	201	2,610
Charles River at Waltham, Mass.	225	11	2,540	1.0	775	2,540
Mother Brook* at Dedham, Mass.	---	5	874	0.3	90.4	900

*Mother Brook at Dedham, Massachusetts is an artificial Canal which diverts waters from the Charles River at Dedham and carries these waters into the Neponset River.

---Drainage area undeterminable.

TABLE IV

EXPLANATORY NOTES
Concerning the table of
SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

Column 1. Town or City. Municipalities, arranged alphabetically, where available information positively indicated the existence of an organized sewerage system.
Column 2. Population 1930. Entire population of the civil division as reported by the 1930 Census.
Column 3. Population Served. Best available estimate of the persons served by an organized system.
Column 4. Discharge in thousand gallons per day. The best available estimate of the volume of sewage discharged.
Column 5. Treatment. Abbreviations, noted below, indicate the type of treatment applied to the domestic wastes.
Column 6. Chief sources of Industrial Wastes. The industries which commonly pollute streams are indicated by concise reference to the type of plant, product or raw material.

Symbols

--	No information available
(P)	Partial
(s)	Summer resort.
(S)	State Institution
(U)	College or University
Various	Several industries present with none clearly predominant.
Milk	Refers to pasteurizing, ice cream and dairy plants.
Fert.	Fertilizer factory.
Oil	Petroleum products; storage or distribution plants.
Gas	Illuminating gas manufacturing plant.
Cannery	Includes fish packing.

Im.	Imhoff Tank	A.	Aeration.
Sp.	Septic Tank	Cl.	Chlorination
SF.	Sand filtration.	St.	Settling
F.	Filtration.	Sc.	Screening (fine)
CP.	Cesspool	Br.	Barging sludge to sea.
Sl.	Sludge treatment.	Sm.	Sedimentation
AcSl.	Activated sludge plant.	Ir.	Irrigation

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments

TABLE IV-C

SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

MASSACHUSETTS COASTAL BASINS

	Domestic Sewage				Industrial Wastes
Town or City	Pop. 1930	No. of Services	Discharge thous. gal/day	Treatment	Chief Sources
Arlington, Mass.	36,094	--	2,220	None (n)	--
Belmont	21,748	--	1,370	None (n)	--
Beverly	25,086	--	--	None	--
Boston	781,188	--	88,000	None (n&s)	Various
Braintree	15,712	--	--	None (s)	--
Brookline	47,490	--	4,790	None (s)	--
Cambridge	113,643	--	12,066	None (n)	Various
Canton	5,816	--	705	None (s)	Various
Chelsea	45,816	--	--	None (n)	--
Dedham	15,136	--	1,061	None (s)(P)	Laundry
Everett	48,424	--	--	None (n)	--
Fairhaven	10,951	--	--	none	--
Franklin	7,028	860	223	Sm.SF.	Textiles
Gloucester	24,204	--	--	none	--
Hull	2,047	--	--	none	--
Lexington	9,467	--	700	none (n)	--
Lynn	102,320	--	--	none	--
Malden	58,036	--	--	none (n)	--
Marblehead	8,668	--	--	none	--
Marion	1,638	242	129	Sm.SF.	--
Medfield	4,066	--	71	SF.	Bricks
Medford	59,714	--	--	none (n)	--
Melrose	23,170	--	--	none (n)	--
Milford	14,741	1,834	362	Sm.Im.F.(P)	Rubber
Millis	1,738	--	150	Sm.SF.(P)	Various
Milton	16,434	--	890	none (s)	Chocolate
Nahant	1,654	--	--	none	--
Nantucket	3,578	1,631	705	SF.	--
Needham	10,845	--	825	none (s)(P)	Textiles & rubber
New Bedford	112,597	--	--	none	--
Newton	65,276	--	4,784	none (s)	Textiles & rubber
Norwood	15,049	--	1,470	none (s)	Printing
Peabody	21,345	--	--	none	--
Plymouth	13,042	--	--	none	--
Quincy	71,983	--	6,066	none (s)	Leather
Reading	9,767	--	--	none (n)	--
Revere	35,080	--	--	none (n)	--
Salem	43,353	--	--	none	--
Somerville	103,908	--	8,696	none (n)	--
Stoneham	10,060	--	--	none (n)	--
Stoughton	8,204	--	735	(2)	Clothing & rubber
Swampscott	10,346	--	--	none	--

MASSACHUSETTS COASTAL BASINS (continued)

Town or City	Domestic Sewage: Pop. 1930	No. of Services	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Wakefield, Mass.	16,318	--	--	none (n)	--
Walpole	7,273	--	1,065	none (s)	Various
Waltham	39,247	--	2,285	none (s)	Various
Watertown	34,913	--	2,160	none (s)	Various
Wellesley	11,439	--	1,055	none (s)	Textiles
Winchester	12,719	--	--	none (n)	--
Winthrop	16,852	--	--	none (n)	--
Woburn	19,434	--	--	none (n)	--

(n) North Metropolitan District sewer system.
(s) South " " " "
(2) Connection to South Metropolitan District system under construction

EXPLANATORY NOTES
concerning tables of the
ORGANIZED WATER SUPPLY SYSTEMS

Column 1. Town or city. Municipalities, arranged alphabetically, where available information indicates the existence of an organized public or semi-public water supply system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 census.

Column 3. Population Served. Best available estimate of the persons served by an organized system (as for the year 1936).

Column 4. Consumption in thousand gallons per day. Best available estimate of the normal daily requirement.

Column 5. Sources of supply. The type of source drawn from is indicated by symbols:- R. for Reservoir, Pond or Lake; W. for Wells, either deep or shallow; Spr. for Spring; Str. for Streams.

Column 6. Watershed area in square miles. Best available estimate of the drainage area upon which the water supply is dependent.

Column 7. Capacity in millions of gallons. Best available estimate of the quantity of water stored by, or immediately available to, the municipal supply.

Column 8. Type of Treatment. Available information concerning the methods used to improve the quality of the water served.

SYMBOLS

(2), etc. Numerals enclosed in parentheses indicate the number of separate water supply systems which serve the municipality. Where there is only one system no symbol is necessary.

(S) Includes State institution
(T) Includes Summer population served
(U) Includes College or School
(s) Provides Summer service only
(a), (b), etc. Letters enclosed in parentheses link civil divisions served by the same water source:-
In column 3 and 4 they link municipalities where available information does not give the number served in each town.
In column 5 letter indicates that the civil division imports water.
In column 6 and 7 letter indicates that the civil division exports water.
Letters link municipalities within one state and basin; cross-references between basins or states appear in footnotes.

Symbols (continued)

A.	Aeration
Al.	Alum
AlSl.	Aluminum sulphate
Am.	Ammonia
AmSl.	Ammonium sulphate
AS.	Alum - Soda Ash
CC.	Corrosive correction
Cl.	Chlorine
Co.	Coagulation
CuSl.	Copper sulphite
F.	Filter
IR.	Iron removal
K.	Activated carbon
L.	Lime
MF.	Mechanical filter
PF.	Pressure filter
pH.	Correction of reaction
RF.	Rapid filter
S.	Soda Ash
SF.	Slow filter
Sm.	Sedimentation
SoCl.	Sodium hypochlorite
St.	Storage of protective significance.

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments
Annual Reports, Public Utilities Commissions

Table V-C

ORGANIZED WATER SUPPLY SYSTEMS

MASSACHUSETTS COASTAL BASIN

Town or City	Population 1930	Population Services	Consumption thou. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal.	Type of treatment
Abington, Mass.	5872	1495	627(a)	R.	.6(a)	563(a)	Cl.
Acushnet	4092	637	84	(n)	---	---	None
Arlington	36094	7391	2218	(b)	---	---	Cl.
Barnstable (2)	7271	1513	489	W. & (p)	---	---	None
Belmont	21748	4818	1373	(b)	---	---	Cl.
Beverly	25086	5715	1629	R. & Str.	5.7(q)	2055(q)	Co Sm RF Cl
Boston	781188	101566	87868				Cl.
Metropolitan Water Supply							
Ware River				Str.	100(b)	none(b)	
Wachusett Reservoir				R.	109(b)	67,000(b)	
Sudbury River System				R.	93(b)	15,712(b)	
Swift River (under construction)				R.	187(b)	415,000(b)	
Bourne (4)	2,895	277	---	W.	---	---	None
Braintree	15,712	4,300	1,215	(m)	---	---	Co.Sm.RF.Cl.
Brookline	47,490	8,008	4,792	W. & (b)	---	---	IR.A.Sm.SF.
Cambridge	113,643	13,978	12,066	R.	24.8	2,903	Co.Sm.RF.A.Cl.
Canton	5,816	1,377	704	W.	---	---	CC. Cl.
Chatham	1,931	460	142	W. & R.	---	---	None
Chelsea	45,816	5,808	3,329	(b)	---	---	Cl.
Cohasset	3,083	999	309	W. & R.	---	---	A.Co.Sm.RF.Cl.
Danvers	12.957	3,043(c)	1,193(c)	R. & (c)	1.63	599	Cl.
Dartmouth(2)	8,778	1,325	258	W. & (n)	---	---	None
Dedham	15,136	3,782	1,061	W.	(d)	(d)	None
Duxbury,	1,696	899	246	W.	---	---	None
Edgartown	1,276	631	130	W.	---	---	None
Everett	48,424	7,406	4,429	(b)	---	---	Cl.
Fairhaven	10,951	2,434	422	W.	---	---	None
Falmouth	4,821	3,028	784	R.	---	---	CC
Franklin	7,028	1,409	670	W.	---	---	Cl. (P)

ORGANIZED WATER SUPPLY SYSTEMS

MASSACHUSETTS COASTAL BASIN (continued)

Town or city	Population 1930	Population Services	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal.	Type of treatment
Georgetown, Mass.	1,853	103	--	W.	--	--	IR. A. F.
Gloucester	24,204	6,246	1,910	R.	--	--	Cl. (P)
Hanover	2,808	487	121	W.	(f)	(f)	none
Hanson	2,184	--	99(p)	(a),(f),&(g)	--	--	--
Hingham	6,657	5,363(h)	2,134(h)	R.	.7(h)	432(h)	CC.Cl.
Holbrook	3,353	--	(k)	(m)	--	--	none
Holliston	2,864	404	95	R.& W.	--	--	Cl. (P)
Hull	2,047	(h)	(h)	(h)	--	--	CC. Cl.
Ipswich	5,599	1,642	258	R.	4.6	64	Cl.
Kingston	2,672	843	249	W.	--	--	none
Lexington	9,467	2,531	703	(b)	--	--	Cl.
Lincoln	1,493	438	--	R.	.8(i)	300(i)	none
Lynn	102,320	17,850	7,320	R.& Str.	(r)	(r)	Cl.
Lynnfield (2)	1,594	200	38	W.&(r)	5.6	--	Cl.
Malden	58,076	9,766	3,923	(b)	--	--	Cl.
Manchester	2,636	1,129	394	R.& W.	--	--	none
Marblehead	8,668	2,831	776	W.	--	--	IR.A.Sm.SF.
Marion	1,638	747	198	W.	--	--	none
Marshfield	1,625	1,800	271	W.	--	--	none
Mattapoisett	1,501	500	103	W.	--	--	none
Medfield	4,066	354	71	W.	--	--	none
Medford	59,714	10,691	3,598	(b)	--	--	Cl.
Medway	3,153	700	237	W.	--	--	Cl.
Melrose	23,170	6,038	1,568	(b)	--	--	Cl.
Middleton	1,712	(c)	(c)	R.	1.63(c)	599(c)	Cl.
Milford	14,741	3,085	814(j)	W.& Str.	3.5 (j)	384(j)	SF. CC, Cl.
Millis	1,738	--	150	W.	--	--	none
Milton	16,434	4,225	891	(b)	--	--	Cl.
Nahant	1,654	919	259	(b)	--	--	Cl.
Nantucket (2)	3,678	2,210	603	W.	--	--	none
Needham	10,845	2,998	824	W.& Spr.	--	--	CC.Cl.(P)

Table V-C

ORGANIZED WATER SUPPLY SYSTEMS

MASSACHUSETTS COASTAL BASIN (continued)

Town or city	Population 1930	Population Services	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal.	Type of treatment
New Bedford, Mass.	112,597	17,590	9,112	R.	(n)	(n)	none
Newton	65,276	15,114	4,784	W.	--	--	CC. Cl.
Norwood	15,049	2,719	1,223	R. & W.	.5	400	A. SF.
Oak Bluffs	1,333	1,525	161	Spr.	--	--	none
Peabody	21,345	4,450	2,831	R.	2.1	1266	Cl.
Pembroke	1,492	159	(p)	(g)	--	--	--
Plymouth	13,042	3,204	1,200	R.	--	--	none
Provincetown	3,808	1,008	396	W.	--	--	none
Quincy	71,983	17,038	--	(b)	--	--	Cl.
Randolph	6,553	--	626(k)	R.	3.5(m)	600(m)	Co.Sm.RF.Cl.
Reading	9,767	2,629	680	W.	--	--	IR.A.SF.Sm.
Revere	35,680	6,409	2,264	(b)	--	--	Cl.
Rockland	7,524	--	(a)	(a)	--	--	Cl.
Rockport	3,630	1,000	383	R. & W.	--	--	Cl. (P)
Salem	43,353	7,194	4,347	(q)	--	--	Co.Sm.RF.Cl.
Saugus	14,700	3,636	874	(r)	--	--	Cl.
Scituate	3,118	2,465	534	W. R.& Spr.	4.2	--	Co.Sm.RF.CC.Cl.(P)
Sharon	3,351	844	369	W.	--	--	none
Somerville	103,908	13,962	8,696	(b)	--	--	Cl.
Stoneham	10,060	2,425	712	(b)	--	--	Cl.
Stoughton	8,204	2,056	734	R.	1	5	none
Swampscott	10,346	2,751	893	(b)	--	--	Cl.
Tisbury	1,541	702	264	Spr.	--	--	none
Topsfield	986	20	--	W.	--	--	none
Wakefield	16,318	3,620	735	R. & W.	.9	--	Cl.A.SF.(P)
Walpole	7,273	1,568	1,065	W.	--	--	none
Waltham	39,247	6,350	2,287	W.	--	--	none
Wareham (2)	5,686	2,599	376	W. & R.	--	--	none

Table V-C

ORGANIZED WATER SUPPLY SYSTEMS

MASSACHUSETTS COASTAL BASIN (continued)

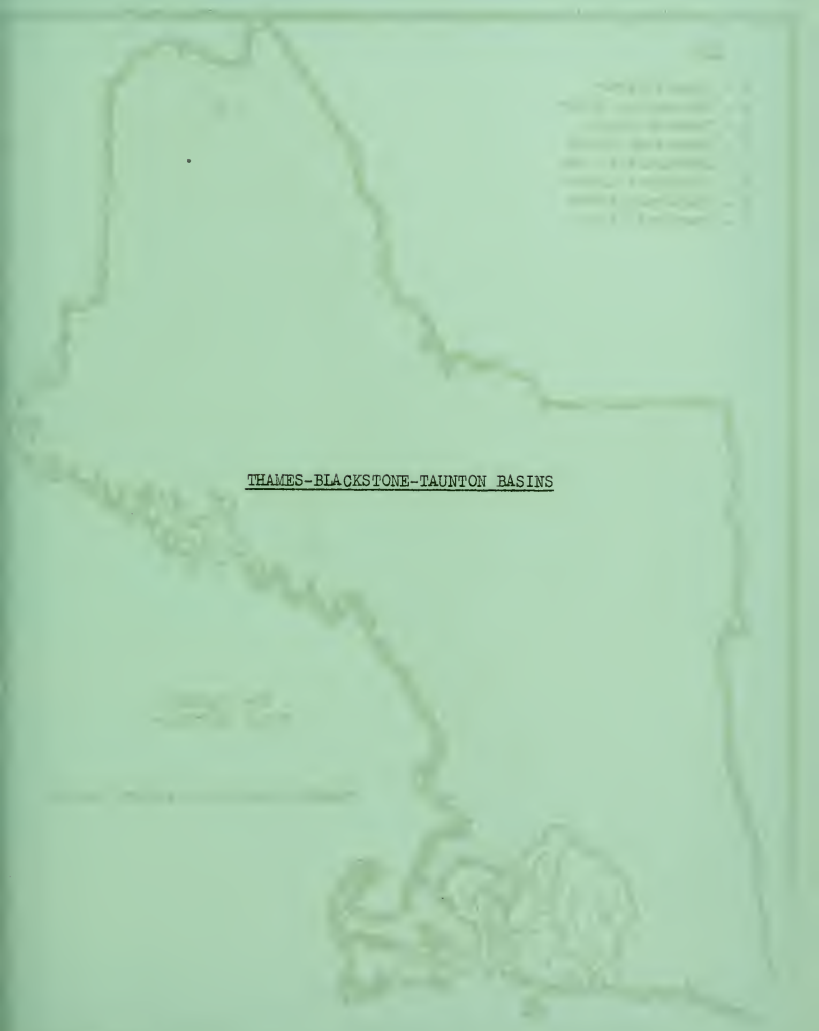
Town or city	Population 1930	Population Services	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal.	Type of treatment
Watertown, Mass.	34,913	6,142	2,160	(b)	--	--	Cl.
Wellesley	11,439	3,365	1,053	W.	--	--	CC. (P)
Weston (2)	3,332	665	215	W.	--	--	none
Westwood (2)	2,097	163	--	W. & (d)	--	--	none
Weymouth	20,882	6,960	1,676	R.	--	--	Co.Sm.RF.
Wilmington	4,013	634	157	W.	--	--	none
Winchester	12,719	3,158	1,037	R.	1.3	994	Cl.
Winthrop	16,852	3,860	1,195	(b)	--	--	Cl.
Woburn	19,434	3,980	1,830	R. & W.	7.5	500	Cl. (P)
Wrentham	3,584	552	155	W.	--	--	none
Yarmouth	1,794	136	67	W.	(p)	(p)	none

Notes: (b) Boston - Metropolitan Water Supply.
(g) Brockton. (see Taunton Basin)
(i) Concord, Mass. (see Merrimack Basin)
(j) Includes Hopedale (see Blackstone Basin)

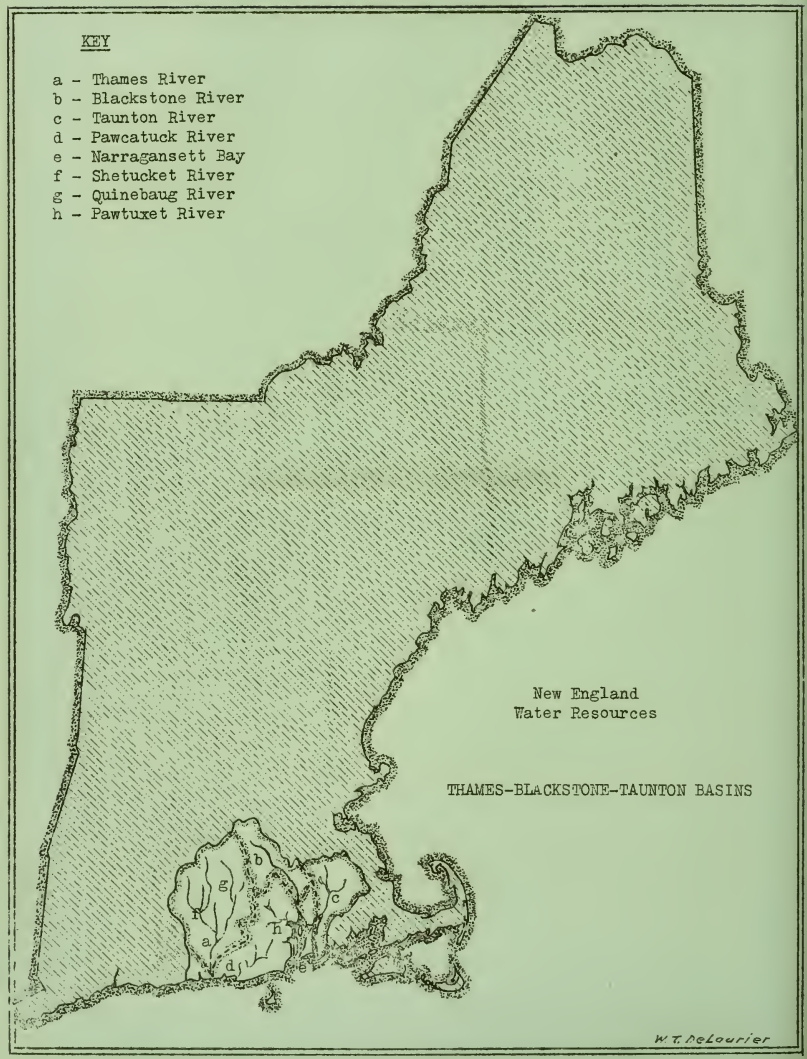
TABLE VI-C

EXISTING WATER POWER - MASSACHUSETTS COASTAL BASINS

RIVER	NO. OF PLANTS IN Mass.	CAPACITY OF PLANTS OF over 10,000 HP.	1,000 to 9,990 HP.	under 1,000 HP.	CAPACITY USED FOR Utility	Mfg.	TOTAL CAPACITY Horse-power
MASSACHUSETTS COASTALS	13	0	0	2,555	300	2,255	2,555
Charles	5	0	0	840	0	840	840
Neponset	4	0	0	980	0	980	980
Others	4	0	0	735	300	435	735



THAMES-BLACKSTONE-TAUNTON BASINS


KEY
a - Thames River
b - Blackstone River
c - Taunton River
d - Pawcatuck River
e - Narragansett Bay
f - Shetucket River
g - Quinebaug River
h - Pawtuxet River
New England
Water Resources
THAMES-BLACKSTONE-TAUNTON BASINS
W.T. DeLourier

THAMES-BLACKSTONE-TAUNTON BASIN

This basin, located in the southeastern part of New England, includes the entire state of Rhode Island and portions of the states of Massachusetts and Connecticut. The chief water bodies in the region are the Blackstone, Thames, Taunton and Pawcatuck rivers, and Narragansett Bay.

It contains centers of high population density and industrial activity. The important cities in this district are Worcester, Brockton, Taunton, and Fall River in Massachusetts; Woonsocket, Pawtucket, and Providence in Rhode Island; and Norwich and New London in Connecticut.

There are located on these streams many textile plants which contribute large quantities of industrial pollution to the rivers. These industrial wastes, together with the untreated domestic sewage from a majority of the communities in the district, cause seriously polluted conditions along the rivers, especially in their lower reaches.

Narragansett Bay, into which many of these streams flow, receives this pollution, with the result that the recreational uses and the shellfish industry in the bay are greatly impaired.

Water supply sources of good quality, both surface and underground, are adequate for the needs of the region. Many supplies are already developed, but ample opportunities are available for the development of additional supplies when and if needed.

The fall in the Blackstone, Thames and some of the smaller rivers has been almost completely utilized by manufacturing plants and, in a few places, public utility developments. This fall is developed at a great many low head privileges, ranging from 4 to 31 feet. Little opportunity exists for additional power developments on these streams.

Both natural and artificial storage tend to lessen flood heights on the rivers. Floods are infrequent and flood losses which occurred in 1927 and 1936 were attributed to the failure of dams, and to the constriction of river channels at points of damage. Had the storms of 1927 and 1936 been as intense here as they were farther north, flood damages would have been measurably increased.

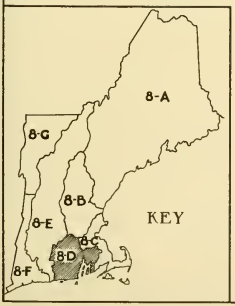
Commercial shipping and pleasure boating make full use of the navigation facilities of Narragansett Bay and other coastal waters. The tidal portions of the larger rivers are maintained open to navigation. Opportunities exist for improvement of these facilities by deepening channels, dredging harbor anchorages, and constructing breakwaters.

MAP Nº 8-D

NOTE.
INVESTIGATION OF SANITARY PROBLEMS ON: BRANCH, MOSHASSUCK AND WOONASQUATUCKET RIVERS IN R.I; TAUNTON AND BLACKSTONE RIVERS IN MASS AND R.I; QUINEBAUG AND FRENCH RIVERS IN MASS.

Legend

- SEWAGE SYSTEM-NO TREATMENT
- SEWAGE SYSTEM-TREATMENT
- CONSTRUCTION PROJECT
- I INVESTIGATION PROJECT DEC. 1 1937



NEW ENGLAND WATER RESOURCES

SEWAGE AND POLLUTION

THAMES, BLACKSTONE AND TAUNTON BASINS

SCALE

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

MAP Nº 9D

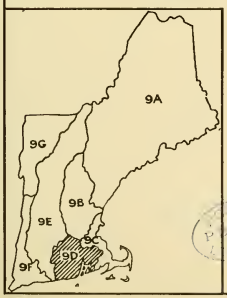
Legend

- WELL, SPRING, SURFACE } NO TREATMENT
- WELL, SPRING, SURFACE } TREATED MECHANICALLY
- WELL, SPRING, SURFACE } TREATED WITH DISINFECTANT
- WELL, SPRING, SURFACE } MECHANICALLY TREATED AND DISINFECTED
- INSIDE SYMBOL OF SUPERIMPOSED SYMBOLS INDICATES TREATMENT OF ALL.
- SUGGESTED PROJECT
- I INVESTIGATION PROJECT

NEW ENGLAND WATER RESOURCES

DEC. 1, 1937

WATER SUPPLIES
THAMES, BLACKSTONE AND TAUNTON BASINS



SCALE

5 0 5 10

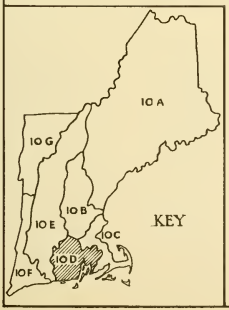
NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE — DISTRICT NO 1
2100 FEDERAL BUILDING — BOSTON MASSACHUSETTS

MAP Nº 10D

NOTE: PROJECT NOT MAPPED WOULD PROVIDE NEW STATIONS TO COLLECT HYDROLOGIC DATA.

Legend

- D DRAINAGE
- E BEACH EROSION CONTROL
- F-C FLOOD CONTROL
- I INVESTIGATION OR STUDY PROJECT
- H-C HEADWATERS CONTROL
- N NAVIGATION
- ○ BASIN-WIDE PROJECT



New England Water Resources

Recommended Projects

EXCEPT WATER SUPPLY AND POLLUTION PROJECTS

Thames, Blackstone and Taunton Basins

DEC. 1, 1937

SCALE

8 0 8 16

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

THAMES RIVER BASIN

GENERAL DESCRIPTION

The Thames River is a tidal estuary extending about 15 miles north from Long Island Sound at New London, Connecticut, to Norwich, Connecticut, at the junction of the Yantic and Shetucket Rivers, its principal tributaries. The Thames basin comprises an area of 1473 square miles, of which 1159 are in Connecticut, 253 in Massachusetts, and 61 in Rhode Island. The major axis of the basin, extending north and south, has an extreme length of about 65 miles, while the maximum width of the basin is about 40 miles.

The general topography of the watershed above Norwich is hilly, with elevations of 600 to 1000 feet along the margins of the watershed. While the maximum elevation is about 1200 feet along the northwestern divide, the average elevation of the basin is only about 500 feet.

The predominant rock structure of the Thames basin is granite, although there are large areas of sedimentary schist in the western portion. The soil, principally glacial deposit, is, for the most part composed of light sand and gravel, but in certain areas is fairly heavy and fertile.

About 30% of the basin is in cleared farm land, two-thirds of which is pastured. The remainder of the basin is woodland, predominantly second and third growth hardwoods, with scattered stands of white pine. In many localities good stands of coniferous trees are to be found in the steep banks of the main streams.

The average annual precipitation in the basin is about 44 inches, ranging from about 43 inches in the northern part to about 46 near the southwestern rim. The summer temperature averages about 68° throughout the basin; while the average temperature for the winter varies from 30° to 24°, according to the distance from the ocean.

The principal streams in the Thames Basin are the Shetucket, Quinebaug, French, Willimantic, Natchaug and Yantic Rivers. The drainage areas of the principal streams in the basin are given in the following table:-

River	Point	Tributary to	Drainage Area Sq. Mi.
French	Mouth	Quinebaug	112
Five Mile	Mouth	Quinebaug	77
Moosup	Mouth	Quinebaug	88
Pachaug	Mouth	Quinebaug	60
Quinebaug	Mouth	Shetucket	744
Hop	Mouth	Willimantic	81
Willimantic	Mouth	Shetucket	225
Natchaug	Mouth	Shetucket	170
Little	Mouth	Shetucket	46
Shetucket	Mouth	Thames	1264
Yantic	Mouth	Thames	98
Thames	Norwich	---	1362
Thames	Mouth	---	1473

The Quinebaug River rises in eastern Hampton County, Massachusetts, and flows southeasterly about 30 miles, crossing the state line to join the French River at Mechanicsville about 8 or 9 miles below the state line. Thence it flows south nearly 40 miles to join theShetucket River at a point 3 miles above the Thames. Its total length is about 62 miles, in which distance there is a total fall of about 612 feet. The upper portion of the river has a slope of 413 feet in the 26.5 miles between East Brimfield, Massachusetts and Putnam, Connecticut, while in the portion below Putnam the drop is only about 199 feet in 36 miles. Numerous lakes and storage reservoirs in the basin are effective in maintaining a fair stream flow during the dry season.

The French River, the most important tributary of the Quinebaug, has its source in Leicester, just west of Worcester, Massachusetts, and flows south 25 miles to its junction with the Quinebaug at Mechanicsville. Five percent of its drainage area is water surface, the largest proportion of water area for any of the major streams of the Thames basin.

The Shetucket River is formed by the confluence of the Willimantic and Natchaug rivers at Willimantic, Connecticut. From this point, it flows southeasterly and southerly for 18 miles to Norwich, where it joins the Yantic to form the Thames. Its drainage area of 1264 square miles comprises 85% of the entire Thames watershed. More than half this area lies in the watershed of its principal tributary, the Quinebaug River. In the Shetucket there is a drop of 145 feet, of which 122 feet are developed for water power. The river is navigable at its mouth and is tidal for about half a mile upstream.

The Willimantic River has its source in the vicinity of Stafford Springs, Connecticut, and flows in a southerly and southeasterly direction for a distance of 23.5 miles to Willimantic. The total fall between Stafford Springs and the mouth is about 354 feet.

The Natchaug River rises to the south of Phoenixville and flows southeast to its confluence with the Willimantic River. There is a total fall of 263 feet in a distance of about 16 miles.

The Yantic River rises in northwestern New London County and flows easterly for a total distance of about 15 miles, in the course of which there is a fall of about 330 feet.

At several gaging stations on the main river and its tributaries discharge records are kept by the State of Connecticut in cooperation with the U. S. Geological Survey. The longest record is that of the flow at Jewett City, Connecticut, on the Quinebaug River. Detailed data for these stations can be found in the Water Supply Papers of the U. S. Geological Survey, and in the reports of the Connecticut State Water Commission.

Table III-D gives stream flow data summarized from the Survey's Water Supply Papers and from unpublished records in the District Engineer's office at Hartford, Connecticut. The hydrograph on Chart 10 shows the mean monthly discharges in cubic feet per second per square mile based on the Jewett City records for the past 15 years. The mean annual runoff from the 712 square miles of drainage area above the Jewett City gage is 1.66 cubic feet per second per square mile.

HUMAN OCCUPANCY

Population The population of the Thames basin in 1930 was 205,000, about one-eighth of the total population of Connecticut. The population of the entire basin is divided as follows: Connecticut, 161,000; Massachusetts, 43,700; Rhode Island, 1300. The increase between 1920 and 1930 was 8.5%, about one-half the growth rate for Connecticut as a whole. The average density of population is only 140 per square mile, in contrast to about 350 per square mile in the adjoining Connecticut portion of the Connecticut River basin. This low density is reflected in the smaller proportion of urban population -- about 50% -- as contrasted with the high urban percentage in other parts of Connecticut and with the state average of 70%.

Only six communities in the basin have over 10,000 population as of 1930:

	Population	Change 1920-1930
New London, Connecticut	29,640	+15.6
Norwich, "	42,478	+ 9.4
Groton, "	10,770	+17.4
Windham (including Willimantic) Connecticut	13,773	- 2.6
Southbridge, Massachusetts	14,264	None
Webster, "	12,992	-2.6

Only about 50% of the Groton population lives in this watershed. In two towns there are between 8000 and 9000 inhabitants; most of the remaining population is in small mill villages located at water power sites on the rivers.

Communities that gained or lost inhabitants between 1920 and 1930 are shown on Map . It will be noted from the above table that there was a material net gain in the larger communities. Of the several towns that lost in this period, most were located on the outer edges of the basin. The increase in population in this area in the next 25 years will, on the basis of the past trends, be less than the predicted increase of about 14% for the entire state of Connecticut.

Agriculture The rural population of the basin contains a higher percentage of farmers than does the rural population of Connecticut as a whole, although the soil of the watershed is not so well suited to farming as is that of the state as a whole; the value of farm land per acre is less than one-half of the average value for the state. Farming is on a one-man scale and much of it on a part-time basis. Dairying, poultry raising and general farming are the principal agricultural activities. The low agricultural productivity in the three Connecticut counties which comprise most of the Thames basin is indicated by the fact that although these counties contain approximately 40% of the farm lands of the state, the value of their farm products is less than one-fourth of the total value for the state. It is significant that the percentage of foreign-born or mixed parentage in the farm population of Connecticut increased between 1920 and 1930 from about 51% to 58%. This high ratio of foreign element is in contrast to the average of about 25% in the three northern New England states.

In spite of unfavorable soil conditions there was in the three counties involved an increase of over 25% between 1930 and 1935 in land used for farms and likewise a substantial increase in the number of people living on farms. This situation was clearly the result of the drop in industrial employment. Inasmuch as the farm land is below the average of Connecticut land in fertility and is better suited to forestry than to farming, the principles of rural zoning could well be applied. The prospects for agricultural development are not favorable, and Connecticut State College has indicated the need of giving technical help to those engaged in farming. Part-time farming, now widely practiced, will undoubtedly increase in the future.

Industry This region is not so highly industrialized as the western portion of the state, the value of its manufactured products amounting in 1933 to only about one-seventh of the total for Connecticut. Its industries are confined principally to establishments of moderate size located in small communities. Textile manufacturing, both cotton and woolen, is predominant and accounts in a large measure for the marked decrease in industrial activity during the depression. New London is an active manufacturing point and also an important transportation terminus for railroad and steamship lines. Norwich and Willimantic are primarily textile manufacturing towns. In the Massachusetts section, Southbridge is a center for the production of optical goods and Webster of textiles and light metal products. During the depression the Thames region, where textile manufacturing was the chief industry, suffered heavy losses in contrast to those experienced in western Connecticut, where the industries were varied. The State Planning Board instituted a study of the industries in eastern Connecticut with the hope of pointing out means of improving the manufacturing situation.

Mining There is a small amount of stone quarrying carried on in the central part of the basin.

Lumbering Lumber production throughout Connecticut has declined steadily since a brief active period ending in 1912. Although the Thames basin contains several state forests, wooded water supply lands and forest land in private ownership, more than 90% of this growth is immature, and only a small portion is in the timber class. Consequently revenue from forest lands comes largely from the sale of cordwood and fencing cut on farm woodlots. Only a minor portion of the total farm income is so produced.

A large-scale program of reforestation is needed in the basin, not only for the protection such a development would afford the water supply lands, but also as a solution of the serious rural problems existing in the submarginal farm areas.

Fishing Commercial fishing is not an important industry in this region. At Groton, at the mouth of the Thames River on Long Island Sound, fish canning was once attempted on a large scale but the undertaking has since been abandoned.

Recreation The Eastern Highland region of Connecticut, largely drained by the Thames system, contains a larger proportion of water supply land than any other section of the state. Lands necessarily acquired

for water conservation purposes have been developed for recreation as well; in addition, more than 20,000 acres are held in state ownership and various recreational facilities have been developed. Moreover, the Resettlement Administration holds options on about 10,000 acres of submarginal farm land, much of which will be devoted only to forestry and recreation.

The proximity of this area to centers of population in Connecticut, Rhode Island and Massachusetts creates a demand for the fullest use of natural recreational opportunities. Industrial and domestic wastes pollute the main stream and some of the tributaries in a degree sufficient to prevent swimming, discourage boating and hinder fish migration. Amelioration of this condition would enhance the value of the basin as an area of intensive recreational activity.

Transportation The only navigable part of the river system is the Thames between New London and Norwich, the head of tidewater. The width and depth of this section is ample for pleasure craft. From Long Island Sound to New London the channel depth is 33 feet; from New London for about five miles upstream it is 25 feet; and from there to Norwich, 18 feet. The annual volume of commercial traffic to Norwich and other points above New London approaches 500,000 tons.

The basin is served by a system of main and secondary highways adequate for its own needs. In addition, it lies in the path of certain regional highways now under consideration. If constructed as planned, to connect eastern New England with western Connecticut and New York, they will cross the basin at the north, near Norwich, and near New London. New London, in the southern section of the valley, is on the main line of the N.Y.N.H.& H.R.R. between Boston and New York. Additional railroad service is provided by the line from Boston to Hartford, passing through Putnam and Willimantic, and by the Central Vermont Railway running north from New London. The N.Y.N.H. & H. line from New London to Worcester is used primarily for fast passenger and freight service from New York to points in Maine. In many sections highways bus and truck lines supplement the railroads.

There is no scheduled air transport service from any point in the valley; Hartford, Providence and New Haven are the nearest points where such service is maintained. There is a state airport at Groton and there are landing fields at Putnam, Willimantic and Southbridge.

WATER USE AND CONTROL

Pollution The Quinebaug River and its tributary, the French River, rise in Massachusetts and undergo serious pollution before entering Connecticut. The Quinebaug is polluted by industrial wastes plus the treated and untreated sewage from Southbridge. The sewage filter beds at Southbridge were reconstructed in 1935 to effect a higher degree of purification of the effluent, but the present treatment works are still inadequate, with the result that large quantities of untreated sewage are being discharged directly into the Quinebaug. Provision for adequate treatment of the sewage of this town is needed.

The French River is polluted by the mixed wastes from Oxford, Dudley and Webster. In these three towns, where the combined population nears 22,000, there are no treatment works. The Massachusetts State Department of Health has urged, for a number of years, the construction of treatment plants at Dudley and Webster.

The degree of pollution of the Quinebaug River is increased along its course by the domestic sewage and industrial wastes discharged at the various towns through which it flows. Pollution in the river below Putnam has been appreciably reduced since the construction, within recent years, of a treatment plant which partially purifies the sewage by settling. Conditions in the lower portion of the Quinebaug River would be greatly improved if treatment plants were constructed at Danielson and Jewett City.

The Natchaug River, in its lower reaches, receives raw sewage discharged at Willimantic. Analyses of the Shetucket below Willimantic have shown decided pollution. The Willimantic River near its upper end, at Stafford Springs, receives partially treated sewage and, in addition, large volumes of wool scourings, a particularly offensive industrial waste.

Norwich, the largest city in the Thames basin, with a population of nearly 33,000, discharges its sewage into both the Yantic and Quinebaug rivers. A project now under way calls for the construction of an intercepting sewer, river crossing syphons and a sewage treatment plant, which will treat the sewage from a large part of the city, and will therefore reduce the pollution in the Thames. A further benefit will be the abatement of the nuisance now caused by the deposit of sewage solids in certain localities at ebb tide.

New London, at the mouth of the river, is provided with a sewer system which collects domestic sewage from 75% of its 30,000 population. A sedimentation plant treats about 10% of the sewage; the remainder, untreated, is discharged through six outlets into the harbor and sound. The New London sewage, augmented by the diluted sewage brought down by the streams and by oil from the numerous ships which navigate the lower river, causes objectionable pollution in New London Harbor.

There are numerous towns in this basin where sewer systems and treatment plants should be constructed in the near future in order to eliminate obnoxious stream conditions. The larger communities might well consider providing at least partial treatment for their sewage, such as sedimentation and perhaps provision for chemical precipitation

and chlorination. The tributary streams, especially the larger ones, have potential value for recreational as well as industrial uses which should not be destroyed by impure conditions in the streams.

Water Supply Six of the ten Massachusetts communities in the basin have water supply systems: two are privately owned; three are municipally owned; and one is under the control of a water district. Southbridge, which has the largest system, treats its reservoir supply by aeration and slow sand filtration. The supplies of the other communities are from ground sources and are untreated.

In Connecticut, the sources of supply are, with two or three exceptions, surface waters. The water is of good quality and except in a few cases chlorination is used. The largest single drainage area used for water supply is that of the Natchaug River. This supply, after filtration and chlorination, serves Willimantic. Such purification of the water for domestic uses is necessary, although the river is relatively clean compared with other larger streams in the vicinity. The necessity for purification is even greater along the entire length of the Quinebaug River.

The majority of the water supplies in Connecticut are owned by private water companies; however, the larger supplies of this region -- at Putnam, Norwich, Willimantic and New London -- are served by municipally-owned works.

Although many communities in the basin do not yet have organized water supply systems, ample opportunity for the development of surface water sources will still exist if and when the need is sufficiently urgent.

Flood Control Flood conditions on the Thames River up to March 1936 did not involve excessive damage. The topography of the Yantic, Shetucket and Quinebaug basins is not conducive to high discharges, and the stream pattern of the Thames basin is such that the runoff does not produce cumulative peak flows, but is distributed along the main streams. Because of many dams on the rivers, the natural channel storage has been eliminated, with the result that flood peaks are slightly increased. The numerous natural lakes and artificial reservoirs, together with the considerable ground storage provided by the soil, largely glacial in character, are effective means of retarding flood runoff.

The New England storm of November 1927 did not center on and did no great damage in the valley, the total losses amounting to only $74,000. The freshets of March 1934 and January 1935 caused greater discharges on the rivers of the basin than did the 1927 flood.

In 1936 the Quinebaug exceeded its previously recorded flood levels by 7 feet. All gaging stations registered discharges greater than ever before, and in many cases the maximum discharges were double and triple the previous maxima. The maximum concentration of runoff was recorded at Willimantic on the Natchaug River in the amount of 84.0 cubic feet per second per square mile. The peak runoff of the Quinebaug was 59.9 cubic feet per second per square mile, occurring at Quinebaug, Connecticut. The estimated damage in the valley approached $4,000,000,

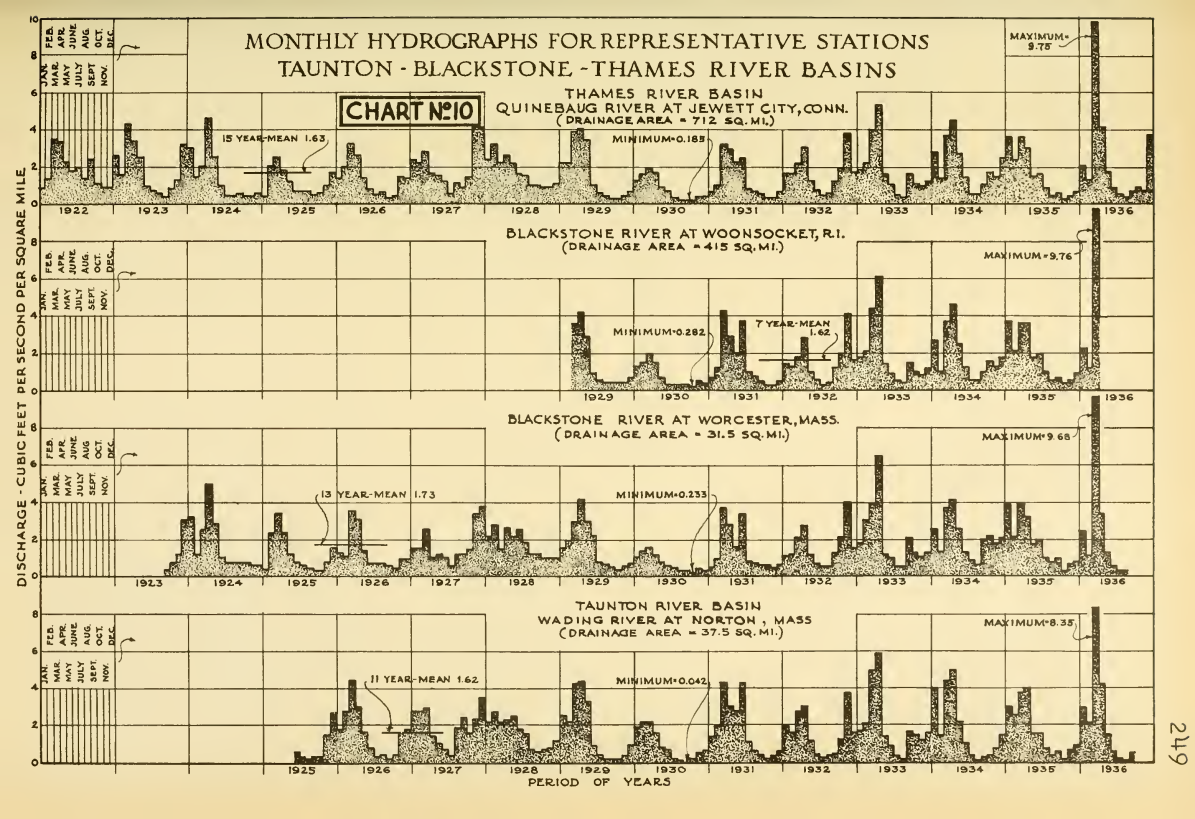
much of which was incurred at Webster and Southbridge, Massachusetts. The heavy rainfall of nine or ten inches over the area southwest of Worcester at the headwaters of the Quinebaug, coupled with the unusually deep snow cover, caused high runoff in the Quinebaug basin. A great storm centering on the Thames basin could produce much greater discharges than that of 1936.

In 1930 the Army Engineers did not recommend any expenditures for flood control in the valley because flood damages during the previous fifty years had been small and such as had occurred were due to ice jams or failure of poorly designed dams and bridges. No authorization was given by the Flood Control Act of 1936 for an examination and survey of the Thames River.

Power The Thames River, being a tidal estuary, has no power developments. Its tributaries, the Yantic, Shetucket and Quinebaug rivers, have long been developed for water power largely for textile and other manufacturing, although there are some hydro-electric plants which are units of, or interconnected with, large distributing systems.

The report on the developed and undeveloped power in the basin made by the U. S. Army Engineers in 1930 (published as House Document #644), 71st Congress, 3rd Session), lists 81 developed sites with a total head of 1332 feet and a combined installed wheel capacity of 40,016 horsepower. Of this total head, 1139 feet are utilized at manufacturing plants and 193 feet at electric utility plants. The corresponding installed wheel capacities are respectively, 29,078 and 10,938 horsepower. The greater portion of the developed head is in Connecticut and amounts to 824 feet, with corresponding wheel capacities of 34,128 horsepower.

The investigations of the Army Engineers disclosed six power sites, four on the Quinebaug River and two on the Natchaug River, as economically feasible for development. Wheel capacities of 5.2 cubic feet per second per square mile were selected for sites where the available storage and pondage was sufficient to regulate completely the runoff from the drainage area. Where less storage was available, a wheel capacity of 4.5 cubic feet per second per square mile was used, and for still less, 3 cubic feet per second per square mile. Further assumptions of 80% efficiency, 90% utilization and primary power of 2.15 horsepower per foot of head per 100 square miles of drainage area were made in arriving at the estimates of potential power output.


MONTHLY HYDROGRAPHS FOR REPRESENTATIVE STATIONS
TAUNTON - BLACKSTONE - THAMES RIVER BASINS
CHART Nº10
THAMES RIVER BASIN
QUINEBAUG RIVER AT JEWETT CITY, CONN.
(DRAINAGE AREA = 712 SQ. MI.)
15 YEAR-MEAN 1.63
MINIMUM=0.185
MAXIMUM= 9.75
BLACKSTONE RIVER AT WOONSOCKET, R.I.
(DRAINAGE AREA = 415 SQ. MI.)
MINIMUM=0.282
7 YEAR-MEAN 1.62
MAXIMUM=9.76
BLACKSTONE RIVER AT WORCESTER, MASS.
(DRAINAGE AREA = 31.5 SQ. MI.)
13 YEAR-MEAN 1.73
MINIMUM=0.233
MAXIMUM=9.68
TAUNTON RIVER BASIN
WADING RIVER AT NORTON, MASS
(DRAINAGE AREA = 37.5 SQ. MI.)
11 YEAR-MEAN 1.62
MINIMUM=0.042
MAXIMUM=8.35
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
DISCHARGE - CUBIC FEET PER SECOND PER SQUARE MILE
PERIOD OF YEARS
1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936

Listed below, in tabular form, are data taken from House Document #644 for the sites which it would be economically feasible to develop:-

Dam Site	Drainage Area Sq. Mi.	Average Head Feet	Maximum Utilized Flow CFS	Potential Horse Power Capacity at 80% eff.	Average Yearly Output Thousand Kw-Hrs
Quinebaug River, Conn.					
Shetucket	743	26.5	2226	5363	17,897
Canterbury	601	26.7	1809	4391	12,956
Pomfret Landing	345	18.2	1035	1713	5,070
Quinebaug River, Mass.					
East Brimfield	56	22.0	293	586	1,107
Natchaug River, Conn.					
Mansfield Hollow	159	46.0	715	2990	6,430
Chaplin	71	107.8	213	1917	6,180

The total head for these six sites is 247.2 feet and the corresponding estimated total wheel capacities and yearly output are, respectively, 16,960 horsepower and 47,640,000 kilowatt-hours.

Additional sites, with heads totaling about 550 feet, were also investigated, but the high costs of power production made these sites infeasible for development. A site at Coventry, Connecticut, on the Skungamaug River, a tributary of the Willimantic, could be developed to utilize 225 feet of fall. The resulting storage of 19,254 acre-feet would completely control the runoff from the 25 square miles of drainage area and would furnish water for a wheel capacity of 2526 horse power, producing a yearly output of 5,000,000 kilowatt-hours. However, because of the excessive flowage damage, the cost of power production would be 2.25 cents per kilowatt-hour.

The largest of the undeveloped sites adapted to economical development is at Shetucket. It would utilize all the head of the Quinebaug River between the pond of the Connecticut Light and Power Company at Taft Station, Connecticut, and the tailwater of the Aspinook Company at Jewett City. The cost of construction was estimated in 1930 at $112 per horse power, and of power production, 0.52 cents per kilowatt-hour. The Canterbury development would utilize all the head between the pond of the Aspinook Company and the tailwater of the Wauregan Company at Wauregan. It would be the second largest development of the group. The estimated cost of the development was $131 per horse power, and of power production, 0.61 cents per kilowatt-hour. The development of the site at Pomfret Landing, Connecticut was started shortly after the World War but was abandoned before much progress had been made. This development would utilize all the head between the Goodyear Cotton Mills pond at Goodyear, Connecticut, and the tailwater of the lowest power development at Putnam. If this station were to be operated automatically from some central station in a power system, the cost of power would be materially less than $161 per horse power and 0.83 per kilowatt-hour, the estimated cost of operation as an isolated plant.

The only economical development in Massachusetts would be at East Brimfield, at the upper end of the Quinebaug River. Its economy would lie, not in its development as a hydro-plant, inasmuch as the cost of power would be $737 per horsepower and the cost of power production 4.79 cents per kilowatt-hour, but rather in its reservoir capacity. A storage of 14,700 acre-feet, obtainable in the top 15 feet, could be used during the dry months through a total head of 424.2 feet now developed on the river below and would produce 4,481,000 kilowatt-hours at 70% efficiency. With an assumed value of 1 cent per kilowatt-hour thus produced, the additional investment required to produce the 1,107,000 kilowatt-hours at the East Brimfield plant would make the cost of production 1.44 cents per kilowatt-hour. The Army Engineers advocated further and more detailed investigation of the cost of the development by the power users on the river below, who would be benefited by the storage.

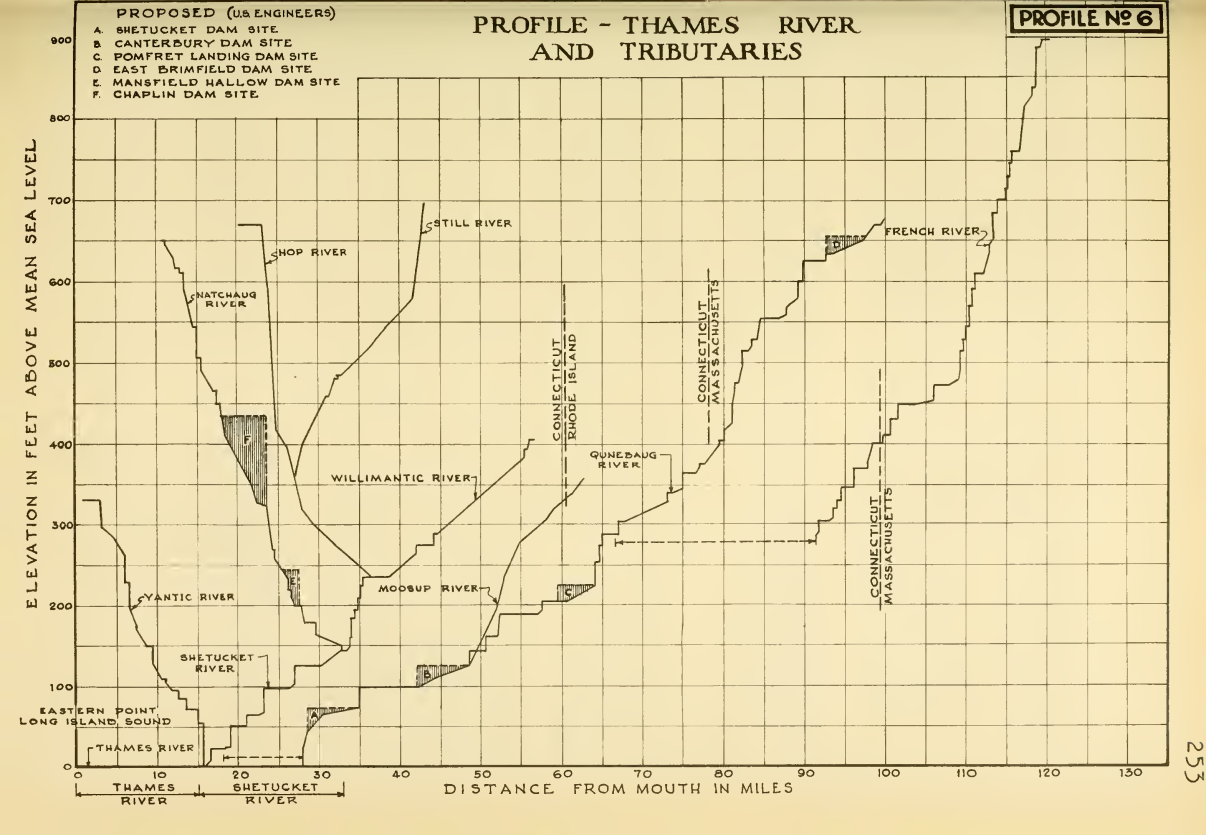
The Mansfield, Connecticut, site on the Natchaug River would utilize all the head from the reservoir of the city of Willimantic to, and including most of, the head upon the Gardner Hall, Jr., Company dam. The storage capacity of the reservoir would be 2870 acre-feet in the top 2 feet and 7575 in the top 12 feet. This could be used as peak load storage and, when coupled with the storage in the Willimantic reservoir immediately below, complete regulation of the stream flow might be possible. The estimated cost of power was $177 per horsepower and the production cost 1.10 cents per kilowatt-hour.

The sixth of the group, at Chaplin, Connecticut on the Natchaug River would be of most value as an automatic peak-load station in a power system. Its storage is not large, only 4370 acre-feet; the cost of power would be $307 per horsepower and the cost of production, 1.23 cents per kilowatt-hour.

The feasibility of the six plants described above is predicated on the assumption that the distribution of power would be supplemented through interconnections with a large power system having steam reserve, in order that the hydro-station might have a market for all power produced. This would require that these stations be operated as base-load stations during the periods of abundant water and as peak-load stations during dry seasons. Without standby power the amount of prime power available is so small that the developments would be impractical.

Navigation The Thames River proper is navigable throughout its full length of about 15 miles. At New London, where one of the depest harbors on the Atlantic Coast is located, the state has constructed a wharf 1000 feet long at a cost of $1,000,000. Two miles above New London there is located a U. S. Submarine Base. In addition to its use for commercial purposes, the river is used for pleasure boating and for the annual Harvard-Yale crew races.

The river for the entire length from its mouth to Norwich was first improved for navigation in 1836. The present channel from the ocean to New London is 33 feet deep; from New London to Allyns Point it is 25 feet deep; and thence to Norwich, 18 feet deep.


PROPOSED (U.S. ENGINEERS)
A. SHETUCKET DAM SITE
B. CANTERBURY DAM SITE
C. POMFRET LANDING DAM SITE
D. EAST BRIMFIELD DAM SITE
E. MANSFIELD HALLOW DAM SITE
F. CHAPLIN DAM SITE
PROFILE - THAMES RIVER AND TRIBUTARIES
PROFILE Nº 6
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DISTANCE FROM MOUTH IN MILES
STILL RIVER
SHOP RIVER
NATCHAUG RIVER
FRENCH RIVER
CONNECTICUT RHODE ISLAND
CONNECTICUT MASSACHUSETTS
CONNECTICUT MASSACHUSETTS
QUINEBAUG RIVER
WILLIMANTIC RIVER
YANTIC RIVER
MOOSUP RIVER
SHETUCKET RIVER
EASTERN POINT LONG ISLAND SOUND
THAMES RIVER
THAMES RIVER
SHETUCKET RIVER

The volume of commercial traffic in 1936 was reported as 638,724 tons in New London Harbor, and 429,615 tons in the Thames River from the railroad bridge at New London to Norwich. The largest freight item was coal. Direct railroad transfer facilities are available at several wharves.

In 1935 Congress authorized deepening the channel between Allyns Point and Norwich to 25 feet, but no funds have yet been allotted for the project. The Chief of Engineers' 1936 report states "$820,000 can be profitably expended during the fiscal year 1938 by completion of the channel above Allyns Point". A much-needed improvement in New London Harbor conditions has been realized by dredging a straight channel to the State Pier.

Drainage Because the slopes of the basin are moderately steep, swamps are few in number; those which do exist are found in land pockets and in localities bordering water bodies. Extensive settlement has already necessitated drainage of some areas; the need for future improvement of scattered wet lands, although improvable, will be determined by the rate of future growth.

Erosion Approximately 98% of the Thames watershed has been classified by the Soil Conservation Service as having little or no erosion. Small areas marked by occasional gullies are to be found in the vicinity of Webster, Massachusetts. The most serious condition recorded, moderate sheet erosion, occurs in two localities, one southwest of Putnam, and the other northwest of Norwich. Doubtless the most impressive evidence of erosion is the presence of silt on the stream and pond bottoms, although siltage has not yet become serious in the basin.

Recreation The Thames basin, including most of the Eastern Connecticut Highlands, is the logical region to serve the recreational requirements of industrial sections within and near the valley. Already large areas have been purchased to protect public water supplies and an additional 3% of the drainage basin has been purchased for forest, wildlife, or recreation uses. Until the experiments now being carried on by the Resettlement Administration in connection with developing recreation and wildlife facilities have been completed, the solution of the land use and recreation problems cannot be determined. These experiments will tend to satisfy the existing demand for new pleasure outlets which has resulted from the excessive pollution of the larger streams in the Thames system.

Any increase in the number of wildlife and fish is retarded both by pollution and by extensive hunting and fishing. Preservation of, and maximum return from, the potential wildlife population requires improvement of favorable habitats and thorough enforcement of game laws.

BLACKSTONE RIVER BASIN

GENERAL DESCRIPTION

The Blackstone River has a drainage area of 540 square miles, of which 380 are in Massachusetts and 160 in Rhode Island. The basin is about 41 miles long and 13 miles wide. The river rises to the north of Worcester, Massachusetts, flows in a generally southeasterly direction a distance of about 52 miles, and empties into Providence Harbor, the northern-most arm of Narragansett Bay. The length of the river in Massachusetts is 31 miles; in Rhode Island, 21 miles. The five-mile stretch of the river below the lower dam at Pawtucket is a tidal estuary known locally as the Seekonk River.

The drainage area is generally rolling, comparatively low and not well defined, except for sections in the western part of the watershed. Rock structure is predominantly granite, covered in general by sandy soil, some of which is moderately fertile. The water area is about 17 square miles, or less than 3½% of the total area. Lake Quinsigamond, having an area of 546 acres, is the largest body of water in the basin.

About 60% of the total area is woodland of rather sparse density in which there is little timber value. More than 10% of the area, primarily in the western and northern parts of the basin, is devoted to crops. The remainder of the area is largely in industrial and residential development.

The rainfall in the Blackstone valley varies from 42" at Worcester to 47" at Providence, with an average of about 45" for the basin as a whole. The precipitation is fairly uniform throughout the year, but is slightly lower during the fall than in the other seasons. The average winter temperature is about 20°; that of summer about 69°.

The principal tributaries are shown in the following table:

River	Enters at	Drainage Area - Sq.Mi.
Quinsigamond	Fisherville, Mass.	38
Mumford	Uxbridge, Mass.	58
West	Uxbridge, Mass.	35
Branch	Blackstone, Mass.	95
Mill	Woonsocket, R. I.	35
Ten Mile	East Providence, R. I.	56

The Branch River drainage area lies almost wholly in Rhode Island. The river enters the Blackstone in Massachusetts just north of the State Line. The Ten Mile River enters the Blackstone at tidewater, although the Ten Mile River itself is not a tidal stream, owing to the low dam built across its mouth.

Discharge records for the Blackstone Basin are obtained by the U. S. Geological Survey at gaging stations located at Worcester, Mass., in operation since 1923, and at Woonsocket, Rhode Island, in operation since 1929. The mean annual runoff at these stations, in cubic feet per second per square mile, is, at Worcester, 1.73 (D.A. 31.5 sq.mi.);

at Woonsocket, 1.54 (D.A. 415 sq. mi.). Detailed flow data for the stations can be found in the Water Supply Papers of the U. S. Geological Survey.

The figures in Table III-D are taken from records in the office of H. B. Kinnison, District Engineer at Boston, as well as from the Survey's Water Supply Papers in Part I - "North Atlantic Slope Basins". Hydrographs of the monthly average runoff during the period of record at these stations are shown on Chart 10.

HUMAN OCCUPANCY

Population The population of the Blackstone basin in 1930 was 503,000, 42% of which was in Rhode Island. As contrasted with an increase of 11% between 1920 and 1930, there was a loss of nearly 3% between 1930 and 1935. In the latter period the loss in the entire state of Rhode Island was about 1%. This decrease was due to the various factors of the industrial depression, particularly the inactivity and abandonment of many textile properties. The Rhode Island section of the basin is the more thickly settled, having in 1930 a density of 1350 per square mile in contrast to 770 in the Massachusetts section, and to an average of 470 in the three southern New England states. The high degree of population concentration and industrial activity of the region is indicated by its inclusion in the "metropolitan" and "industrial" area classifications set up by the U. S. Census.

Nine-tenths of the population is classified as urban. The urban population is found in many small industrial villages as well as in the following cities and towns with populations of over 10,000:

Mass.	Portion in basin	Population 1930	Rhode Island	Portion in basin	Population 1930
Attleboro	95%	20,700	Central Falls	100%	25,898
No. "	100%	10,197	Cumberland	100%	10,304
Worcester	100%	195,311	E. Providence	50%	15,000
			Pawtucket	90%	69,400
			Providence	10%	25,300
			Woonsocket	100%	49,376

Providence, with a total population of 252,981, East Providence, Pawtucket and Attleboro are not entirely within the Blackstone basin. Cities and towns that gained or lost in population between 1920 and 1930 are shown on Map 7 . Of the losses that occurred between 1930 and 1935, 80% were in the Rhode Island area. Worcester, Massachusetts, lost about 4000 population in spite of its varied lines of industry.

The possibilities of the future growth of the Blackstone valley are demonstrated in the consistent increase in the population of metropolitan Providence and of Worcester between 1900 and 1930. In the 1920-1930 decade the increase for the valley was 11.4% -- slightly more than the average increase for New England; in this period only four towns (each under 10,000) lost population. Between 1930 and 1935 there was a loss of nearly 12,000, or about 2.5%, in Worcester, Providence and other major cities, as well as in a few small towns. While some of the latter may continue to lose population on account of the closing down of the industries on which they were dependent, it seems probable from past trends that the larger communities and the basin as a whole will resume a moderate growth.

Agriculture The farming lands of the watershed are comparatively fertile and are developed in small holdings, the principal activities being dairying, poultry raising and general farming. Part-time farming

is widely practiced. In rural development no marked change is anticipated. There will probably be a moderate increase in the rural nonfarm population and in the class who practice part-time farming.

Industry The Blackstone valley is one of the oldest and most highly developed industrial sections in New England, partly as the result of the availability of water for power and processing in the early stages of industrial development. For these purposes the river is extensively and almost completely utilized. Providence, at the southern end of the basin, is the principal center of population and transportation, and is the seat of a variety of manufactures. North of Providence, Pawtucket and Woonsocket are prominent industrial centers, particularly for the manufacture of cotton and woolen textiles. Worcester, at the northern end of the valley, is a major transportation center, and is outstanding as an industrial city, known especially for its metal industries. In addition to the manufacturing carried on in the larger cities, there are many plants, mostly textile, located in small communities along the Blackstone River and its tributaries. Because textile plants were predominant among the industries of the valley, the decline in textiles brought severe industrial losses to this section.

Future industrial developments in this region will depend upon the success attained in replacing the vanishing textile activities with other lines of manufacture. Industrial bodies throughout New England have made organized efforts to this end, and have progressed materially in attracting to this region new and varied manufacturing enterprises. Providence, Pawtucket and Woonsocket have had signal success in establishing new industries of various types in plants formerly used for textile manufacture. The region has such favorable factors as an ample supply of skilled labor, cheap power, adequate transportation facilities and proximity to large markets; all of these factors provide a sound foundation for growth.

Mining Except for a limited amount of stone quarrying in the southern part of the basin there are no mining operations in this region, nor are there prospects for mining activities in the future.

Lumbering Forest products, confined principally to cuttings for cordwood and fencing on farm woodlots, provide only a minor part of farm income.

Recreation Due to the proximity of areas that have better natural recreational features, recreation in this basin is of primary importance only to its own population. The larger ponds are in constant use for swimming and boating, and many minor streams and ponds, well stocked with fish, provide extensive sport. The main stream and its major tributaries are so seriously polluted that they are unsafe for swimming, undesirable for boating and detrimental to fish life.

Transportation The tidal section of the Blackstone River, called the Seekonk, is navigable throughout for commercial vessels, from its mouth up to Pawtucket. The minimum channel depth is now about 13.5 feet, although an Army Engineers' project, completed in 1927, called for a

depth of 16 to 18 feet. There has been local agitation for channel improvements up to the head of tidewater to accommodate larger commercial vessels, but provision for navigation above that point, is not considered necessary or practicable.

An adequate system of main and secondary highways covers the entire watershed. Supplemental through highways are, however, needed.

While service has been abandoned on some of the minor branch railroads in the valley, the bulk of the population is well served by the main line from Boston to Albany and the west through Worcester, and by the shore line from Boston to New York through Providence. In addition, a line from Boston to Hartford cuts across the center of the basin. Providence and Worcester are connected by a railroad along the Blackstone River. Over this route, however, most of the passenger service is now provided by highway motor busses.

The Rhode Island state airport south of Providence is a scheduled stop on an air transport line between Boston and New York, and is adequate to meet the aviation needs of the lower Blackstone valley. At present there is no scheduled service in the Worcester area; the establishment in this section of a landing field capable of handling large transport planes is desirable.

WATER USE AND CONTROL

Pollution The principal water problem in the Blackstone basin, as well as in the adjoining basins which comprise this group, is the abatement of stream pollution. The presence in the river of domestic sewage and large quantities of untreated industrial wastes which are discharged from the many thickly settled industrial communities along the river has seriously imparied the usefulness of the river for industrial water supply and recreational purposes, and also has virtually destroyed fish life in the main river and some of the tributaries.

Except in the upper reaches of its tributary streams, it is doubtful if the river will ever be used to any extent as a source of municipal water supplies. Elimination of pollution to render the river safe for recreation and habitable for fish life would entail large expenditures incommensurate with the benefits derived.

In general, the conditions in the Blackstone River in Massachusetts are worst near Worcester. Analyses show the most objectionable conditions on the river to be between the city of Worcester and its sewage disposal works.

The sewage from Worcester is completely treated by the Imhoff tank and trickling-filter method, and the daily discharge of effluent amounts to about 21,300,000 gallons. Over one-half of the total industrial waste (15,000,000 gallons daily) discharged into the river in Massachusetts comes from Worcester, mainly from its steel and wire industry. These wastes contain large quantities of iron which cause considerable discoloration of the water and leave deposits along the bed and banks of the stream. During storm periods the stream is further polluted by sanitary sewage discharged directly into the river from the combined sewers of the city.

The towns of Northbridge and Hopedale also have sewerage systems and sewage treatment works. The treatment works of these three communities serve about 80% of the population in the Massachusetts area. If the towns of Auburn, Blackstone, Douglas, Millbury, and Uxbridge, which now discharge their untreated sewage into the river, were to provide treatment works, the percentage would be raised to 91.

About one-third of the total industrial pollution in Massachusetts is received from textile mills located in Uxbridge, Millbury and Douglas.

Lake Quinsigamond, located in Worcester and Shrewsbury, with its water surface of 546 acres, is intensively developed for recreational use. The lake receives pollution from various sources. There are approximately 225 cesspools or privies located within 200 feet of the Worcester side of the lake; although recent examinations showed most of them to be in good order, this potential source of pollution should be removed to obviate any possible contamination of this body of water which is a recreational center for so many people.

The Branch River, the largest tributary of the Blackstone, whose watershed is almost wholly in Rhode Island, receives untreated sewage and industrial wastes from several scattered mill villages along its course. Pollution is noticeable in the lower portions of the river due to the discharge of large volumes of textile wastes. It is in this reach that conditions are seriously objectionable. The degree of this pollution is so great that it can be seen even in the Blackstone below the junction of the two rivers.

To remove this pollution nuisance the Rhode Island State Planning Board recommends the construction, in the near future, of a trunk sewer system in the Branch River valley to serve the villages of Burrillville and North Smithfield, the sewage from this system to be treated and then discharged into the river. Before this plan is adopted an investigation should be made of sewerage and the disposal of sewage and industrial wastes in these towns.

The sewage from most of Woonsocket undergoes treatment by the activated sludge process, the effluent being discharged into the Blackstone River at the rate of 3,400,000 gallons per day. Untreated textile wastes received by the river at this point increase the organic load carried by the stream. By the extension of the sewer system there would be provision for discharge to the municipal treatment plant of the most objectionable wastes and sewage from the mills, together with the untreated sewage of certain sections of the city.

Some of the most serious pollution conditions in the whole valley are centered around Pawtucket and Central Falls, Rhode Island. This area comprises the lower Blackstone from Lonsdale to, and including, the Seekonk River. The Moshassuck River valley, which adjoins the Blackstone on the west, should be considered simultaneously with the Blackstone. This applies particularly from Saylesville to the mouth.

Untreated sewage from the east side of Central Falls is discharged into the Blackstone River at the rate of about 300,000 gallons per day; while the sewage from the west side of the city is treated at a municipal plant and the effluent, amounting to approximately 296,000 gallons per day, flows into the Moshassuck River. Recommendations have been made for the abandonment of the present plant and the discharge of sewage from both districts of the city into the Pawtucket sewer system for treatment at the proposed Pawtucket plant.

There is also a division in the method of disposal of sewage from the city of Pawtucket. Two million gallons per day of untreated sewage from the east side of the city are discharged into the Blackstone River, while the sewage from the west side is discharged into the Providence sewer system for treatment at the municipal plant, located at Fields Point.

Cumberland and Lincoln also discharge untreated sewage and industrial wastes into the river. The district tributary to Abbot Run, a small stream flowing into the Blackstone at Central Falls, presents no difficulties as this area is a protected source of water supply for the city of Pawtucket.

Various plans have been considered for eliminating pollution from the waters of the Blackstone, Seekonk and Moshassuck rivers. The Rhode Island State

Planning Board has recommended investigation of sewerage possibilities for certain villages in the towns of Lincoln and Cumberland, and for a part of the town of East Providence. The Board has recommended also investigation of the proposed trunk sewer which would convey the sewage and industrial wastes of these towns, together with that of the Blackstone valley sections of Central Falls and Pawtucket, to the Pawtucket-East Providence line, at which point a joint disposal plant would be located.

Another recommendation of the Planning Board is the additional investigation of the proposal to collect the sewage and industrial wastes of the Moshassuck valley districts of Lincoln, Central Falls and North Providence by a trunk sewer either for discharge to the Providence sewer system or for pumping to the Blackstone valley district for treatment at a district plant in that valley.

Ten Mile River, with a drainage area of 55.3 square miles, largely in Massachusetts, is tributary to the Seekonk River. There are three communities located in this area: Plainville, Attleboro and North Attleboro. Plainville has no sewer system, but Attleboro and North Attleboro have both systems and treatment works. The Massachusetts State Department of Health has recommended the addition of settling tanks to the present sand filters at Attleboro and the enlargement of the treatment works at North Attleboro to permit more adequate purification of the sewage, thereby reducing the pollution of Ten Mile River. This river is badly polluted in comparison with other New England streams that are used for domestic water supply, and it is urgent that early measures be taken to prevent untreated or only partially treated sewage from being discharged into the river, as well as to provide adequate purification of certain industrial wastes so as to lessen the load on the East Providence water treatment works.

Water Supply This basin is, in general, adequately served with public water supplies for both domestic and industrial purposes. The Massachusetts communities consume about 20,000,000 gallons per day for domestic use, Worcester having the highest consumption, with 14,829,000 gallons, a per capita consumption of 78 gallons. The Worcester system is connected with the Metropolitan District Water Supply and can draw on that supply in emergencies. Only three communities in Massachusetts, Bellingham (pop. 3056), Mendon (pop. 1265) and Millville (pop.1901) are without public or semi-public supplies. Of these, Millville is in greatest need of a supply system. W.P.A. project engineers have recommended the installation of a pumping station, stand-pipe and distribution system, estimated to cost approximately $125,000.

The supply for the town of Blackstone, now obtained from the city of Woonsocket, Rhode Island, has not been found consistently adequate. Within the past two years the results of studies that have been made indicate that the more economical procedure will be for Blackstone to make provisions for an independent supply rather than to extend the present system.

Pawtucket, Woonsocket, East Providence and Cumberland are supplied by municipal systems. Abbot Run, having an estimated yield of 13,000,000 gallons daily, is the source of supply for Pawtucket and Central Falls, and for parts of Lincoln, Cumberland, East Providence and North Providence. Studies have been made with reference to the extension of Pawtucket's system and the installation of a filtration plant. On the basis of the results of these studies, the State

Planning Board is recommending a project for such construction at some time in the future.

The Planning Board feels that the water supply needs of Woonsocket are so urgent that it recommends for early construction a reservoir on Tarkiln Brook, Burrillville, and a pipe line to Woonsocket to provide additional water supply for that city and villages in North Smithfield. Estimates based on plans prepared for this project show the cost to be $2,180,000.

The present supply of Woonsocket, having a yield of about 7,000,000 gallons per day, serves, in addition to Woonsocket, Blackstone, in Massachusetts, and parts of North Smithfield, Cumberland and Lincoln, in Rhode Island.

Water from Ten Mile River is impounded in a 430,000,000 gallon storage reservoir constructed in 1935 as part of the East Providence water supply system. Because the drainage area contains numerous villages and manufacturing plants from which a large amount of pollution enters the stream, it is necessary to treat this water to render it safe for domestic use.

Slatersville gets its water from the Branch River, another polluted stream. Although this water is treated, the results are not always satisfactory. The proposed trunk sewer in the Branch River valley would materially benefit the quality of this supply.

Flood Control The Blackstone River overflowed its banks in both the 1927 and 1936 floods, thereby causing losses of $650,000 and $2,000,000 respectively in these years. Some of the damage from both these floods was due to the failure of dams. This fact indicates that there is need for rigid inspection of dams and spillway structures, followed by essential improvements, repair and reconstruction when and if necessary. Greater spillway capacity should be provided for in many instances.

The high degree of population concentration in the valley (nearly 1000 people per square mile) makes the provision of adequate protective works imperative. The intensity of flood runoff at Woonsocket was only 40 cubic feet per second per square mile at the crest of the 1936 flood. However, the channel capacities are insufficient to confine the water within the banks, a condition which is aggravated by the presence of the large number of dams spaced at intervals averaging slightly more than a mile.

Inasmuch as the compactness of the 34 developments on the main river precludes any material modification in spillway elevations, little opportunity exists for increasing the capacities of these mill ponds. The construction of new storage reservoirs and the enlargement of existing ones have been suggested for the Branch River basin, to serve not only for flood control but also for river regulation. However, on account of lack of available sites it does not appear that flood control can be accomplished by the creation of storage basins alone. It will be necessary also to undertake such local protective measures as removing congestions in the river, enlarging the channel at constricted points, and diking along the bottom lands in order to reduce floods. This treatment applies particularly to the Rhode Island portion of the stream at Woonsocket and Pawtucket.

Pursuant to the Flood Control Act of 1936 the U. S. Army Engineers have made a preliminary examination for flood control on the Blackstone River. The preliminary report recommended further study. A survey for flood control is now in progress on this river. The solution to the flood control problems involved has not yet been determined.

From the foregoing it would appear that the development possibilities in the basin are limited to: (1) the replacement of obsolete, unused and unsafe structures, so as to provide spillway capacity adequate to pass floods of magnitudes such as that in March, 1936; (2) the elimination of channel constriction; (3) the construction of protective works where major flood damages are likely to occur; and (4) the construction and coordination of storage control in the best interests of power, flood control, sanitation, recreation and navigation.

Power There are no large water power developments on the Blackstone River. Of the 471 feet of natural fall in the 45 miles of river between the Electric Light Company dam at Worcester and tidewater, 406 feet have been utilized by 34 dams, which furnish heads ranging from 2 to 31 feet, the majority being not more than 15 feet. At present, 32 feet of the 406 feet are not utilized by reason of the failure of 3 dams; and 59 feet are not utilized due to broken-down hydraulic equipment at several sites. The fall in Rhode Island between the level of the Woonsocket Dam and tidewater, amounting to 147 feet, is completely utilized by the 11 plants in that state.

On the tributaries approximately 675 feet of head are developed, of which amount 300 feet are on the Branch River and one of its tributaries.

Altogether, there is a total wheel capacity of about 25,000 horsepower in the basin, about 9000 horsepower of which is located on the tributaries. Sixty-five percent of the total wheel capacity is in Rhode Island.

Full and efficient use of the installed capacity on the rivers is not obtained because of the lack of pondage and the obsolescence of power equipment. Silting of the mill ponds over a long period of years has made them shallow and of inadequate capacity.

Practically all of the feasible sites on the Blackstone River and its tributaries have already been developed. Whatever potential power there is lies in the redevelopment of existing plants and in the improvement of storage. Most of the mills require more power than can now be obtained from their water wheels. The additional power required is obtained in some cases from auxiliary steam installations; in other cases through purchase from power companies.

Increase in power by storage has long been considered but has been found to be uneconomical. In many cases mills are finding it more economical to purchase outside power and to use the water in their ponds for processing. Reconstruction on the sites of destroyed dams would probably be unsatisfactory because the power thereby obtained would not be so cheap as equal blocks of purchased power.

There are many lakes, ponds and reservoirs within the basin. In Massachusetts alone these number 136, of which 15 have known storage values totaling about 23,000 acre-feet. About 86% of this storage is located on the Mumford, Quinsigamond and Mill rivers and Singletary Brook. Total storage in Massachusetts amounts to 204 acre-feet per square mile of controlled drainage area, 112 square miles. About 20,000 acre-feet of storage is in the watershed of the Branch River in Rhode Island, equivalent to about 3.0 inches of runoff from the drainage area of 97.5 square miles.

Hence the storage above Woonsocket, Rhode Island amounts to about 43,000 acre-feet below spillway level, equivalent to a runoff of about 2.0 inches from the entire drainage area of 416 square miles. The controlled portion represents more than 50% of the total drainage area above Woonsocket. From recent surveys in Massachusetts, it is found that the 15 storage ponds would provide above spillway level an additional 15,000 acre-feet. There is probably about 13,000 acre-feet of additional storage to be obtained in the Branch River watershed. With this additional 28,000 acre-feet of storage, the total storage above Woonsocket would be about 71,000 acre-feet, corresponding to about 3.2 inches depth of runoff from the area. In addition there are indeterminate small amounts of storage in the main valley and in the many small lakes, ponds and reservoirs in the basin. None of these storages have dependable flood control value as they are normally kept full.

Earlier engineering reports have indicated 10 possible sites for storage reservoirs to be used primarily for improving low water flows in the river. These sites, which would provide about 20,000 acre-feet of storage, have not, however, been recommended, because the construction costs would be disproportionate to the probable benefits.

Navigation The channel of the Seekonk River (tidal portion of the Blackstone) extends 5 miles from Providence Harbor to Pawtucket, and has a controlling depth in the upper reach of about 17 feet and a width of 150 feet nearly to the head. The mean tidal range varies from 4.7 to 5 feet. According to the report of the U. S. Army Engineers, in 1936 traffic on the river amounted to 389,445 tons, consisting principally of petroleum products and coal.

Improvements in the channel have permitted small craft such as barges, schooners and small steamers, to use the river. However, with the advent of steamers for carrying bulk freight, the opportunity for water-borne traffic on the river has been limited, owing to the channel conditions at the entrance to the river which prohibit vessels of more than 250 feet in length from passing freely into the river. The State Division of Rivers and Harbors recommends straightening the sharp bend in the channel immediately below India Point, and widening and deepening the channel. A further recommendation of the Division is the erection of bulkheads and filling in along portions of the shore to permit the expansion and improvement of those areas.

Extension of navigation beyond Pawtucket is at present impractical as the stream above the city is confined for about a mile between walls, and the bed is largely ledge rock. Commercial growth may ultimately justify the removal of rock to extend the channel.

Erosion The reconnaissance survey of the Soil Conservation Service classified the entire Blackstone basin as subject to little or no erosion. Nevertheless, siltage has reduced the capacity of some older storage ponds. In these instances the results of erosion have become recognizable in the ponds before a serious condition has become evident upon the land.

Drainage The undulating topography and the complexities of human occupancy in the Blackstone watershed have combined to make drainage problems of secondary importance. Topography restricts swamp areas largely to the coastal slope, and occupancy already has effected material progress in draining those mosquito-breeding swamps which annoyed nearby dense settlements. There are many swamps, however, where the mosquito nuisance still exists. The Massachusetts Health Department has suggested that certain of the more noxious wet lands be drained so that the mosquito nuisance will be abated.

Recreation Although it would be impractical to restore the main river to a condition favorable for bathing and fishing, owing to its use by industrial developments, the elimination of pollution from many of the tributaries is desirable so that the recreational opportunities of the area may be enhanced. The presence of large population centers makes it important that the fullest development be made of potential recreational facilities.

The provision of facilities for water and woodland recreation by public agencies in both Massachusetts and Rhode Island has added much to the recreational advantages of the valley.

TAUNTON RIVER BASIN

GENERAL DESCRIPTION

The Taunton River, the largest and most important stream in southeastern Massachusetts, drains an area of 516 square miles. The basin, extending in a north and south direction, is about 30 miles long and 31 miles wide. The river rises in the southern part of Norfolk County and the northern part of Bristol County, and its easterly sources are in the northern part of Plymouth County. The river flows southeasterly and then southwesterly for a total distance of about 50 miles to Fall River where it empties into Mt. Hope Bay, an arm of Narragansett Bay. Below Taunton the river is tidal for a distance of 20 miles. Above Taunton the river gradient is not steep, the slope being 90 feet in 25 miles.

The basin is generally flat, with few elevations reaching higher than 100 feet above sea level. The western and marginal sections are hilly and rolling. Swamps occupy 3.8% of the drainage area; pond surfaces, 3.2%.

In the eastern section the granite bed rock is overlain with heavy glacial deposits of gravel and sand, while in the western section there is considerable clay bottom.

About 25% of the watershed is cleared farm land, half of which is cultivated. The remainder of the area, except for urban regions, is scrub wood or brush land. The flat and swampy lands in the eastern section are wooded largely with cedar.

The mean annual precipitation is about 46 inches, distributed uniformly throughout the year. The winter temperatures average around 28° to 30°, while the summer average is from 68° to 70°.

The two main branches of the river are the Town and the Matfield, which unite in the eastern part of Bridgewater to form the Taunton. The Matfield River drains an area of 78 square miles, 7% of which is pond and swamp area. The Town River, with a watershed of 60 square miles, flows for a portion of its course through Great Cedar Swamp, a tract of about 7000 acres.

Three Mile River, the largest of any of the tributaries, with a drainage area of 85 square miles, is formed by the confluence of the Wading and Rumford Rivers.

Discharge records for the Taunton River are obtained at State Farm, on the main river, and at Norton, on the Wading River. These stations are maintained cooperatively by the U. S. Geological Survey and the Massachusetts State Department of Health. The records at these stations do not date far back, as the State Farm station was established only in 1929 and the Norton station in 1925.

Based on these records, the mean annual runoff from the 260 square miles tributary to the river at State Farm is 1.72 cubic feet per second per square mile, and the corresponding figure at Norton, from

a drainage area of 42 square miles, is 1.84 cubic feet per second per square mile.

In Table III-D, the flow data at these stations are summarized from records of the U. S. Geological Survey. The hydrograph of monthly flows at Norton on the Wading River is shown on Chart 10.

HUMAN OCCUPANCY

Population In 1930 the population of the basin was 300,000, which represented a gain of less than one percent over 1920 as contrasted with an increase of 10.3% for the entire state of Massachusetts. Due to the industrial character of the region the density is relatively high, 580 per square mile, when compared with the average of 470 in the three southern New England states.

The population is predominantly urban, over two-thirds being in the three cities which have over 10,000 population:

City	Population 1930
Fall River	115,274
Brockton	63,797
Taunton	37,355

About 5% of Attleboro lies in the Taunton watershed. Of the smaller towns in the basin, there are thirteen that have between 2500 and 10,000 inhabitants, and fifteen that have less than 2500.

The population of the Taunton basin was practically stationary between 1920 and 1930 due to the fact that losses in the important cities were offset by moderate gains in smaller communities. The principal losses occurred in the two largest cities; Fall River, a textile manufacturing center, which lost about 4%, and Brockton, a shoe city, which lost slightly less. Between 1930 and 1935 the former regained nearly half of its earlier loss of 5,200, while Brockton continued to decrease to the extent of about 1,400 inhabitants. The Taunton population was practically stationary in the fifteen year period. Population changes between 1920 and 1930 are shown on Map 7 . It will be noted that in this period practically all of the smaller places gained, although slightly; they continued to gain moderately up to 1935. In view of the fact that this region as a whole showed no population gain between 1920 and 1930, when Massachusetts increased 10%, and that the growth of the state in the next 25 years is expected to continue at about the same rate, there may be anticipated only a moderate population increase in this basin.

Agriculture With so large a proportion of the population in the three cities and the industrial towns, less than 10% of the population is classed as rural. Agricultural products yield an estimated revenue of about $8,000,000 per year. The fertility of the soil is above the average of that of the rest of the state. Dairying, market gardening, cultivation of cranberries, and poultry raising are the principal agricultural activities. Part-time farming is carried on by many industrial workers. No marked changes in agricultural activities are anticipated except a tendency toward more part-time farming.

Industry The greater part of this region, one of the principal industrial districts of Massachusetts, lies within the Providence-Fall River-New Bedford industrial and metropolitan areas. In 1935 the total value of products manufactured in the three principal cities was nearly $110,000,000. Cotton textile manufacturing, centered mainly in Fall River and to a lesser degree in Taunton, and shoe manufacturing in Brockton, are the most important industries. The many small towns, however, account for about one-fifth of the total production and employment.

Future development of industry in this region depends largely upon what progress is made in replacing vanishing textile and shoe industries with other manufactures. The fact that Fall River before the depression depended upon textiles for two-thirds of its manufacturing revenue resulted in unusually heavy losses in taxable values and industrial strength when the depression came. Brockton, which had relied principally on the shoe industry, likewise suffered severe losses. Organized efforts to establish new and varied lines of industry have produced appreciable results, but the industrial life of this section will continue to depend on the degree of success attained in the new industries.

Mining Mining operations are comparatively unimportant and are confined to granite quarrying near Fall River. Deposits of anthracite coal have been found in Taunton and other parts of the basin and its extraction has been attempted on a small scale. The results have been unsuccessful due largely to the inferior quality of the coal.

Lumbering Forest products in the basin comprise a moderate amount of farm woodlot cuttings, used principally for firewood and fence posts. Their value is less than one-tenth of that derived from general farm crops.

An increase in the acquisition and development of town forests would be advantageous from the standpoint of future timber production, also from those of water supply and recreation.

Fishing There are no commercial fishing opportunities of consequence within the basin itself, but the shellfish beds of Narragansett Bay are injured by the polluted condition of the water from the Taunton River.

Recreation Three sides of this basin are adjacent to well-favored and highly developed recreational areas. The South Shore, Cape Cod, Buzzard's Bay and Narragansett Bay are centers of attraction not only for hundreds of thousands from New England, but also those from the centers of population in the south and west. The demand for recreational development within the basin is therefore limited. For its own population the basin has a large state forest near Fall River and several small state and municipal forests. To meet the additional demands certain public water supply lands in this area could profitably be opened to controlled recreation of certain types.

Transportation Water transportation in the basin is confined to the Taunton River, which is navigable in its tidal section for a distance of 15 miles, from its mouth to Taunton, although the original channel depth of 11 feet at mean high water above Dighton no longer exists. There is no demand for extension of navigation beyond Taunton. A proposal has been made for the use of the Taunton River as part of an inland waterway to be constructed from Narragansett Bay to Boston Harbor, but investigation has shown that there is at present no economic justification for this project.

The Taunton basin is provided with a good system of main and secondary highways. A new regional highway, recommended in 1937 by the Massachusetts State Planning Board and the New England Regional Planning Commission, would necessitate the construction of a new bridge across the navigable portion of the Taunton River.

Fall River, Taunton and Attleboro are connected with Boston, Providence and New Bedford by N. Y., N. H. & H. R. R. lines. These are supplemented by branch lines and by an extensive bus service throughout the basin.

Facilities for air travel are confined to landing fields at Taunton and Brockton and to a few emergency fields. There are no scheduled air lines operating from any point in the Taunton basin. The development of a modern airport in the Fall River-New Bedford area would facilitate operation of scheduled service.

WATER USE AND CONTROL

Pollution The pollution problem in the Taunton basin calls for local action, principally by the cities of Taunton and Fall River. Pollution from these cities affects both Rhode Island and Massachusetts waters. The situation at Fall River menaces not only public health but also recreational activities and shellfish culture.

Untreated sewage and industrial wastes discharged into the river and its tributaries cause insanitary conditions along the river, particularly near the mouth, at the entrance to Mt. Hope Bay.

The sewage discharged from Brockton and from several state institutions receives treatment before entering the river. The plants at these locations treat about 25% of the domestic sewage in the basin. This percentage would be raised to 80% if Taunton and Fall River were to install treatment plants.

The sewage from Taunton (pop. about 37,500; daily water consumption 2,735,000 gallons) is diluted in the main river, but during the dry season the flow is inadequate to dilute the sewage sufficiently. In the dry season the runoff at the gaging station at State Farm, a few miles above Taunton, amounts on the average to 0.379, 0.167 and 0.204 cubic feet per second per square mile in the months of July, August and September, respectively; hence, if applied to the 344 square miles at Taunton, the respective discharges would be only 130.3, 57.4 and 70.2 cubic feet per second.

Three Mile River, which enters the Taunton River about five miles below Taunton, carries pollution from its two main branches, the Wading and the Rumford rivers. These streams flow through the towns of Foxboro, Mansfield and Norton. Foxboro has a sewerage system which includes partial treatment by sand filtration, but neither Mansfield nor Norton has a system. In the past few years, pollution at the mouth of Three Mile River has shown an increase.

Fall River is the largest seaport city in Massachusetts without satisfactory means of sewage disposal, with the result that serious pollution nuisances occur along the waterfront. The city's population is about 117,000, and the daily consumption of water is in the vicinity of 6,000,000 gallons. This latter figure may be taken as a measure of the amount of sewage discharged through the numerous outlets into the river.

From time to time consideration has been given to the construction of an intercepting sewer and treatment works to relieve the objectionable conditions near the present outlets, and the State Department of Public Health has prepared a plan for such construction. Thus far no action has been taken. As pointed out above, this problem has an interstate aspect in that the pollution of the waters of Rhode Island is partly caused sewage discharged from communities in Massachusetts. Consequently, Rhode Island cannot secure relief without the cooperation of Massachusetts.

Water Supply Seventy percent of the population in the basin is provided with water from public systems. Only nine communities, out of twenty-two, are without such systems. Daily consumption amounts to about 13,000,000 gallons, of which all but 1,000,000 gallons are drawn from the supplies of

Brockton, Fall River and Taunton. The quality of the water is satisfactory, on the whole, there being only two or three instances where chlorination is found necessary and one case, Middleborough, where more extensive treatment is required.

Raynham and Swansea, with populations of 2208 and 4327, respectively, may be singled out as being the two towns in greatest need of new water supply systems, in the interests of public health and fire protection.

Ample opportunity exists for the development of future ground water supplies for the smaller communities in the basin. Where larger surface supplies are required, there are several tributary streams which can be developed. The city of Attleboro takes water from three gravel-packed wells near the west bank of Wading River and from four wells in the Ten Mile River watershed. The present yield of about 1,932,000 gallons per day can, if needed, be increased by the construction of additional wells of the gravel-packed type to provide an ultimate yield of 3,000,000 gallons per day.

Flood Control No necessity for flood control works exists on the Taunton River. Occasional freshets overflow the lowlands along the river, but cause no serious trouble. The valley storage in ponds and swamps absorbs a considerable part of the excess runoff. The history of the river does not include instances of extreme discharges. In 1936, when other rivers in New England were experiencing high flood stages, the peak discharge at the State Farm gaging station on the Taunton River amounted to 3026 cubic feet per second from the 266 mileage of drainage area, a unit discharge of slightly over 11 cubic feet per second per square mile. In cases where mills located above the tidewater portion are affected by freshet flows, local inexpensive measures may be taken to prevent damages.

Power At one time there were over 80 small water power developments on the river and its tributaries, but by 1918, this number had been reduced to fifteen installations, with heads varying from six to twenty-one feet. The total head developed at that time was 198 feet, and the wheel capacities totaled 2250 horsepower. Not all of these fifteen were then in operation, and since then still others have been abandoned and steam plants substituted. Probably not over five hundred horsepower are developed by means of waterwheels on this river at present.

The amount of undeveloped power is so small that in no case would it be economically feasible to undertake development. The cost of such development of hydro power would be much higher than the cost of like amounts of steam power or of purchased electric power.

There is little opportunity for the development of new storage reservoirs or for enlarging existing bodies of water. The topography of the basin is so flat that very few sites are available, and the cost of developing those sites which do exist would be excessive. Great Cedar Swamp on Town River is the one outstanding reservoir site. By constructing a new dam, ten feet higher than the old one, a reservoir of 16,200 acre-feet capacity would be created. In connection with this reservoir, there is a head of nine and one-half feet which could be developed.

Navigation The Fall River waterfront is on the east side of the Taunton River, at the head of Mt. Hope Bay. Terminal facilities consist of 17 piers having 12,000 feet of docking space and wharves providing 7000 feet additional docking space. Three piers have direct railroad connection. The principal cargoes of vessel traffic, which in 1936 amounted to about 2,023,058 tons, are coal and petroleum products. The New England Steamship Company operated until the summer of 1937 a boat line between Fall River and New York. The number of passengers carried in 1936 was 106,707.

A channel 30 feet deep at mean low water and 400 feet wide through Mt. Hope Bay and Fall River Harbor has been dredged to the Brightman Street Bridge. The work authorized is about 90% complete, and it is estimated that the work yet to be done will cost $65,000.

The fifteen-mile channel from Fall River Harbor to Taunton is being deepened and widened as authorized by Congress. The channel will ultimately be 12 feet deep at mean low water and 100 feet wide for most of the distance, narrowing to 60 feet at the upper end. The present depth above Dighton of about 6 feet makes it unsafe for boats drawing over nine feet unless the trip is made on the tide. Construction is about 23% complete, and the Army Engineers have recommended the expenditure of $60,000 on the project for the fiscal year of 1939. The tonnage carried up the river has been greatly reduced in the past ten years, dropping from 75,111 tons in 1927 to 5,474 tons in 1936.

Drainage About 4% of the Taunton basin, or an aggregate area of nearly twenty square miles, is swamp land. These low-lying lands have been partially reclaimed as a measure of mosquito control.

Erosion Soil erosion is not a problem of great significance in the basin, nor has silting of the river occurred to any appreciable extent.

Recreation Although on three sides of this basin there are attractive seashore recreational areas, the swimming facilities near Fall River, Brockton and Taunton can be advantageously augmented. Facilities for other types of recreation, available in the publicly owned forests in the Taunton basin, could well be supplemented by restricted recreational activities on public water supply areas whenever such multiple use can be effected without jeopardizing the water supply.

The lower reaches of the Taunton are so polluted that there is small likelihood of developing a satisfactory environment for game species of fresh or salt water fish.

Only through further stocking of tributary streams and ponds can fresh water fish be maintained in numbers adequate to meet the demands of sportsmen. Extensive development, both urban and recreational, has accelerated the depletion of the wild fowl population in such degree that rigorous protective measures to prevent virtual extinction of those species most sought after by hunters are necessary.

NARRAGANSETT BAY-EASTERN CONNECTICUT COASTAL BASINS

GENERAL DESCRIPTION

This region comprises the state of Rhode Island, except the lower Blackstone and upper Thames basins, and the small portion of eastern Connecticut bordering on Long Island Sound. The area contains a number of coastal streams emptying into Narragansett Bay or Long Island Sound, the largest of which are the Pawtuxet and Pawcatuck Rivers discharging, respectively, into Narragansett Bay and Little Narragansett Bay.

The region has an area of about 1050 square miles, no point in which is more than 25 miles from tidewater. Numerous expanses of swampland are found in this district, particularly along the Connecticut shore and in southeastern Rhode Island. The water area, exclusive of swamps, amounts to nearly 10% of the total area.

The underlying rock formation, largely of granite and other igneous rocks, is, in general, thickly covered with glacial sand and gravel, some of which, particularly near the western portion of Narragansett Bay, is heavy enough to be of definite value as farmland. Over 25% of the total area is cleared farmland, most of it devoted to truck farming. Much of the interior of the region is wooded, with second growth hardwoods predominating.

The average annual rainfall over the district varies from 45 to 48 inches, evenly distributed throughout the year. The temperatures are somewhat less extreme than in other parts of New England, averaging about 30 to 32 degrees in the winter, and 66 to 68 degrees in the summer.

The largest river in the region is the Pawcatuck, an interstate stream which flows through Rhode Island for half its twenty-mile course and for its last ten miles, before discharging into Little Narragansett Bay, forms the boundary line between Connecticut and Rhode Island. The extreme length of the basin is about 23 miles; its maximum width the same. It drains an area of 295.5 square miles, of which 235.1 square miles are in Rhode Island. The river is formed by the union of the Charles and Wood Rivers which drain the great swamp region of southwestern Rhode Island. Its course lies in country which is mostly rolling, but contains ponds and swamps amounting to 9% of the total area.

The river is tidal and navigable as far as Westerly, Rhode Island, five miles above the mouth. Westerly and its surrounding communities contain over 75% of the population in the basin.

The Pawtuxet River, the second largest in the region, has a drainage area of 232 square miles. The extreme dimensions of the basin are 21 miles in length and 19 in width. The main river is formed by the union of the North and South Branches at River Point. The drainage basin is undulating; the soil gravel and sand.

The North Branch watershed contains the Scituate Reservoir, which controls about 40% of the total drainage area and supplies water to Providence and surrounding towns.

The Moshassuck River basin, an area of 22.6 square miles, adjoins the lower end of the Blackstone basin in the cities of Providence, Pawtucket and Central Falls and the town of Lincoln. The waters of this valley are used largely in manufacturing processes at the several mills located along its streams. The river discharges into the Providence River at Memorial Square, in the city of Providence.

The Woonasquatucket River drains a hilly area of 52.3 square miles, having an extreme length of about 13 miles and an average width of about 6 miles. The river discharges into the head of Providence River, at Memorial Square, in the city of Providence. A number of reservoirs located on the tributaries serve to equalize the stream flow, thereby increasing the power values at a number of plants on the main river.

The Potowomut River basin lies southeast of the Pawtuxet basin and adjoins the Pawcatuck basin for a short distance in West Greenwich and Westerly. The drainage area of about 23 square miles lies almost entirely in the town of East Greenwich.

The Pettaquamscutt River basin, covering only 14 square miles, drains parts of the towns of North Kingstown, South Kingstown and Narragansett. The lower portion of the stream is tidal and is commonly called Narrow River.

The Saugatuck River, in South Kingstown, drains an area of 17.5 square miles and empties into Point Judith Pond, a tidal estuary tributary to Block Island Sound. The Annaquatucket River has a drainage area of 9 square miles and flows in an easterly direction to Bissel Cove.

The Mystic River, draining a portion of southeastern Connecticut lying between the Pawcatuck and Thames watersheds, is about 10 miles long and is tidal in its lower portion. The slope of the river is very gradual. The Niantic River, which flows into Long Island Sound about half-way between the mouths of the Thames and Connecticut, is formed by the junction of Great Brook and Lakes Pond Brook, on which is situated the New London Reservoir. Below the junction of the two brooks the Niantic is tidal.

There are no stream gaging stations on the rivers in this region, nor are measurements of runoff available. Applying unit values obtained on streams in adjoining territory, the runoff is estimated at Between 1.55 and 1.65 cubic feet per second per square mile.

HUMAN OCCUPANCY

Population This region contained in 1930 a population of 494,000, of which number about 452,000 were in the Narragansett Bay section and 42,000 in the Pawcatuck basin and adjoining territory in southwestern Rhode Island and eastern Connecticut coastal areas. Throughout this region there is a wide variation in population densities, ranging from 14,000 per square mile within the Providence city limits to less than 50 per square mile in portions of the southern and western sections. Two-thirds of the population lives in one-tenth of the state area, and over 90% in the eastern half. The concentration of population is in the northeastern part, chiefly in Providence and Pawtucket. The growth of the Narragansett Bay region corresponds to that of the entire state of Rhode Island, which showed approximately 14% gain in the 1920-1930 decade and a loss of nearly 1% between 1930 and 1936. The Pawcatuck and Connecticut coastal areas grew only about half as rapidly between 1920 and 1930 as the Bay region.

The urban population comprises 92% of the total. Cities and towns having over 10,000 population are:

	Population 1930	
	Percent in Basin	Total Population
Providence, Rhode Island	90%	252,981
Pawtucket, " "	10%	77,149
Cranston, " "	100%	42,911
East Providence, " "	50%	29,995
Newport, " "	100%	27,612
Warwick, " "	100%	23,196
West Warwick, " "	100%	17,696
Bristol, " "	100%	11,953
Westerly, " "	100%	10,997
Stonington, Connecticut	100%	11,025
Groton, "	40%	10,770

Most of Providence and parts of East Providence, Pawtucket, and Groton lie in this basin. There are, lying wholly or partly within the basin, five towns having populations of between 5,000 and 10,000; 13 towns of between 2500 and 5000; and 13 of less than 2500.

The future trend of Rhode Island population is difficult to predict because of the decrease that occurred between 1930 and 1936. This was a reversal of the increasing trend that had been maintained without a break since 1800. From 1860 to 1910 the average increase was about 25% per decade; from 1910 to 1920, 11%; and from 1920 to 1930, nearly 14%. The individual communities that gained between 1920 and 1930, shown on Map , are nearly all in the thickly settled region of metropolitan Providence. For that matter, these communities showed consistent growth in each decade between 1900 and 1930. Providence gained 6.3% between 1920 and 1930, but lost 4% in the next five years; Pawtucket experienced a 20% gain followed by a 6% loss. The largest losses since 1930 have occurred in metropolitan Providence and in other prominent industrial towns. In general, the smaller places gained slightly. The loss since 1930 is ascribed principally to decreased activity in manufacturing, especially of textiles, and to the closing of numerous mills, followed inevitably by the emigration of many workers.

Towns in the Pawcatuck basin and Connecticut coastal section suffered almost no loss in population through the depression years.

A gain in population in this region will probably accompany future improvements in the industrial situation. It has been estimated by competent authorities that the population in Rhode Island by 1960 would be only 13% more than that of 1930, and that it would become stabilized by that time.

Agriculture In Rhode Island as a whole, of which these drainage areas form the greater part, only 8%, or 52,000 people, are classified as rural, and of this number about 10,000 are listed as rural farm. Of the total state area, two-fifths is farm land, the holdings averaging about 75 acres. The soil in the western part of the state is of low agricultural value but in the eastern half there is some of the best farm land in New England, second only to that of the lower Connecticut valley. Dairy farming accounts for the largest portion of the acreage and of farm revenue, which totaled for the state in 1930 about $10,000,000.

The acreage used for farming in Rhode Island has been decreasing for many years and the only growth has been in the number of small farms -- under ten acres. In the eastern part of the state there is a tendency for large holdings, many of them country estates, to be subdivided for intensive truck gardening purposes or for rural residential use. Part-time farming as an adjunct to manufacturing occupations will probably increase.

Industry The Narragansett Bay region is highly industrialized, leading all others in New England in 1933 in that over half of its workers were engaged in manufacturing. All of the cities listed above, with the exception of Newport and Stonington, are important industrial centers. Textile manufacturing -- cotton, wool and rayon, including dyeing and bleaching -- is the basic industry. Many other lines of manufacture, however, especially in and about Providence, provide a substantial part of the industrial revenue. Most of the industries are located on or near streams draining into Narragansett Bay, comparatively few being in the Pawcatuck basin and eastern Connecticut coastal regions.

The Pawtuxet River, and to a lesser extent, others in the region, provide power and water for numerous mills and receive large quantities of industrial waste. Oil distribution plants at the upper end of Narragansett Bay, important industrial units, present a serious pollution problem.

The trend in manufacturing indicates a change from the heretofore predominant cotton textiles to woolen and worsted, also diversity in the cotton industries toward allied lines such as knit goods, cotton small wares, silk and rayon. Efforts are being made to broaden the industrial base by establishing increasingly varied lines of manufacture.

Mining Stone production in this region is confined principally to granite quarrying, carried on chiefly at Westerly. These quarries, in operation for nearly a century, are noted for the exceptionally fine quality of their stone.

Lumbering Forest products consist principally of cuttings on farm woodlots, supplying a small part of farm income.

The acquisition of additional publicly owned forest land will probably bring about a limited volume of controlled timber production, although such areas will be used for some years primarily for demonstration and recreational purposes.

Fishing Oyster fishing, principally in Narragansett Bay, supplemented by other types of fishing forms an important, although not large industry. The shell fisheries are affected by the polluted condition of the bay, caused by the streams draining into it and by oil from the large distributing plants. Measures have been taken by the state to control and improve the condition of the waters of the bay for the protection of the fishing and recreational interests.

In the Connecticut coastal section of this area commercial fishing is a minor activity.

Recreation There are in this area more than a thousand acres of state-owned land devoted to recreation. The development of additional areas is desirable to meet the needs of the thickly settled communities. The major recreational activities in this region, however, are aquatic sports, which depend not on the acreage of public lands, but on the length of protected shore line. Narragansett Bay and the eastern coast of Connecticut are highly developed centers of recreation, attracting thousands of seasonal residents. A vast amount of private capital has been invested in swimming facilities, yacht clubs, summer homes and hotels.

The waters along the shore of Connecticut between Point Judith and the mouth of the Thames are relatively free from pollution. In Narragansett Bay, however, the tremendous recreational investment is seriously imperiled by industrial and domestic pollution. The Seekonk and Providence Rivers, Apponaug and Greenwich Coves, sections of Warren, Barrington and Bristol, and all of upper Narragansett and Mount Hope Bays have been closed to shell fishing. In all of these waters the degree of pollution is so high that health is actually jeopardized by swimming in them.

Transportation Narragansett Bay is a waterway from the Atlantic Ocean to several important cities: through the Providence River and harbor to Providence; through the Seekonk River to Pawtucket; through Mt. Hope Bay to Fall River; direct to Newport and other points. To accommodate commercial traffic, the largest part of which goes to Providence, channels are maintained from the deeper parts of the Bay to the various ports. There is also local traffic in Bristol harbor, the Warren River and other locations on the Bay.

In the southern coastal section, Point Judith Pond is navigable for vessels of limited draught to the town of Wakefield; the Pawcatuck River, forming part of the boundary between Rhode Island and Connecticut, is navigable for five miles from its mouth to Westerly; Groton and New London are accessible from the ocean through the Thames River and New London harbor.

This region is provided with an extensive system of main and secondary highways. On account of the large volume of traffic - both pleasure and commercial - additional facilities are desirable for the relief of congested routes, especially in the vicinity of Providence. State and regional planning agencies have recommended consideration of constructing

a highway link from Route #1 at a point south of Providence to Fall River and the Cape. Construction of this link, by-passing Providence, would necessitate the erection of a bridge across the northern arm of Narragansett Bay.

Adequate railroad service is provided for practically all the important cities and towns in this area by a network of lines centering at Providence, including the main shore line of the N.Y.N.H.& H.R.R. between Boston and New York, and a line from Newport through Fall River to Boston. In many sections, the railroad is supplemented by highway bus and truck service.

Scheduled air transportation facilities are provided by American Airlines, Inc., at the Rhode Island State Airport at Hillsgrove, about six miles south of Providence. Additional landing fields are located at Charlestown, Newport, Smithfield, Seekonk, and on Block Island. Eastern Connecticut is served by the state airport at Groton in the Thames basin. It will be desirable to establish, eventually, seasonal service from New York to the recreation centers on Narragansett Bay.

WATER USE AND CONTROL

Pollution Scattered throughout the district are numerous communities, most of them small, where public sewers are needed, at least in the principal villages. Construction of sewerage systems in these villages has been slow, chiefly because they have no political entity in themselves and cannot act except with the consent of the towns or townships in which they lie.

Throughout the district industries, large and small, discharge wastes which cause serious contamination of streams. In numerous cases, these industries are not located near any municipal sewerage system and, in some instances, the quality of the wastes is such as to require treatment radically different from that commonly employed for domestic sewage. The problem cannot be solved satisfactorily until comprehensive investigations have been made, until sound and equitable procedures have been formulated. This applies not only to the Narragansett Bay section, but to all similar industrial areas in New England.

There are no active sources of pollution on the Moshassuck River above Sayles Pond; but below this point the river receives industrial pollution from several mills, together with the partially treated effluent from the Central Falls sewage treatment works, with the result that between the Providence city line and the junction with Providence River the river is obnoxious both to sight and smell.

The water in the West River, principal tributary of the Moshassuck, carries industrial pollution and hence is of no help in diluting pollution in the main stream.

The Woonasquatucket receives industrial wastes from the mills along its banks but the general appearance of the river is not greatly affected thereby. Much of the industrial waste discharged by mills within the city limits of Providence is taken by the municipal sewers, but that portion of the waste which is not collected is sufficient to cause visible pollution near the mouth of the river. The pollution at this point is increased by the tidal flow carrying waste originally discharged from the Moshassuck. To rid this river of polluting matter, there has been suggested construction of a trunk sewer in the valley from Georgiaville to the Providence sewers.

The upper reaches of the Pawtuxet valley are sparsely settled, but the lower portion is highly developed industrially. More than twenty cotton, woolen and lace mills discharge their wastes into the river.

On the Pocasset River, a small stream tributary to the Pawtuxet, is situated the city of Cranston, the largest New England city without a municipal sewerage system. A large print works in this city discharges volumes of dye and wash water which, together with the discharge of domestic sewage from individual outlets, grossly pollute the river.

The construction of sewer systems in the Pawtuxet and Pocasset River valleys to serve the city of Cranston, part of Warwick and villages in the towns of Johnston, West Warwick and Coventry is urgently needed. An investigation of the whole problem might demonstrate the feasibility of building a trunk sewer and single treatment plant to serve these communities.

The Seekonk River receives discharges from the Blackstone River, of which it is a continuation; from Pawtucket and Phillipsdale mills; and, along its west bank, from the storm overflows of Providence combined sewers. Deposits of sewage and industrial sludge ranging in depth from a few inches along the west side to several feet in the vicinity of Phillipsdale have accumulated on the river bottom.

The Providence River is the locus for the pollution from the Seekonk, Moshassuck and Woonasquatucket rivers, as well as the treated effluent discharged from the Providence treatment works which is brought upstream by tidal action. The result is gross pollution of the river, a condition which demands rectification.

The Saugatuck River is heavily charged with wastes originating in the manufacturing plants at Peacedale and Wakefield. Wakefield has no sewer system, but domestic sewage from this village reaches the river through several outlets and pollutes the tidal waters of Point Judith Pond. A sewer system and treatment plant should be provided to handle the sewage from the populated part of the area.

Westerly, Rhode Island, located at the head of the Little Narragansett Bay and at the mouth of the Pawcatuck River, has a sewer system and treatment plant which comprises an Imhoff tank and a sludge bed. Above Westerly there is little pollution except at Hope Valley, Louisville and Wyoming, where raw sewage and industrial wastes enter the river.

The thickly settled residential areas along the shores of Narragansett Bay are additional sources of pollution. Large quantities of polluted water from Massachusetts enter Mount Hope Bay, which empties into Narragansett Bay and the Sakonnet River. Tiverton and Newport, having no sewage treatment plants, are likewise sources of pollution.

Considering the unusual recreational advantages of this bay, also the shellfish industry possibilities, improvements in the present methods of sewage disposal are necessary, particularly at Newport, where intercepting sewers and a treatment plant should be constructed.

In the past the problem of oil pollution has been serious in this bay ever since Providence and vicinity became an important oil distribution center. While effective pollution control measures have been established, it is of primary importance that every practicable method be employed to protect the waters of Narragansett Bay from this potential source of contamination.

Water Supply In general, the region has water supplies adequate for both industrial and domestic uses. Many communities which are not at present served by public systems will soon require such systems; in some instances, extensions to existing supplies will be needed.

There are many potential sources of surface water supply located near the headwaters in western Rhode Island and eastern Connecticut, but few of these are near industrial centers. Ground water sources are used by many industrial and small public supplies. In general, these sources are of good quality, although in some cases the iron content is excessive.

Communities along the eastern shore of Narragansett Bay are provided with supply systems. As noted in the Blackstone River section of this Report, East Providence is supplied with completely purified water drawn from the

Ten Mile River. Warren, Barrington, and Bristol have a common supply, completely purified, which is obtained from the Palmer and Kickamuit rivers, whose drainage areas lie almost wholly in Massachusetts. Interstate cooperation is necessary to maintain a reasonable freedom from contamination of these waters. The Tiverton Fire District now obtains water from ground sources, but can, if it becomes necessary, draw upon Stafford Pond.

Newport and part of Middletown, both located on Newport Island, and Jamestown on Conanicut Island are served by the Newport Water Company. The water, completely purified, is obtained from several brooks and from a reservoir on the main brook on Conanicut Island. The present supply is inadequate and studies should be made with a view to constructing a new reservoir.

Within the Pawtuxet River basin is the largest Rhode Island source of supply, the Scituate Reservoir, located on the North Branch of the river. The water from this reservoir, after purification, is used by Providence and parts of North Providence, Johnston, Warwick and Cranston. The storage capacity is sufficient to take care of anticipated needs of these communities. The Pawtuxet Valley Water Company supplies about 350,000 gallons daily to villages along the North Branch of the river, deriving its supply from a small brook above Fiskeville. The water receives chlorination, but even with this treatment it is not of so good quality as are other Rhode Island waters. East Greenwich and Wakefield have individual water supplies, the latter a partially treated surface supply with poor bacterial rating.

The coastal area in the southwestern part of the state is sparsely settled. In the Pawcatuck River basin, Westerly, the largest community, is provided with a well supply. The upper portion of the basin has small population groups and hence presents no difficulties. The swampy nature of large portions of the basin precludes the use of these areas for future surface supplies but, by the same token, well supplies can easily be obtained.

In the coastal area in the southeastern part of Connecticut, the population, for the most part, is served by water supplies. There are a number of streams directly tributary to the Sound which can be utilized for future surface supplies.

Considering the population density in Rhode Island, the water supplies are well regulated. This is proven in part by the low typhoid death rate. Some of the surface supplies need more treatment than they now receive, in order to conform at all times to the standards of purity set by the United States Public Health Service.

Flood Control The Pawcatuck Valley has swampy areas which retard the runoff during freshet seasons. Ponds in the headwaters of Wood River, one of the principal tributaries of the Pawcatuck River, are used as storage basins for stream regulation. The occurrence of damaging floods on the river is infrequent, and such damages as have occurred have generally been due to failure of dams.

Although at a few locations reservoirs might be constructed to reduce further the high water flows, nevertheless, in view of the infrequency of floods and the lack of any decisive trend toward industrial development in this valley, it is doubtful if such construction would be feasible.

On the Pawtuxet River, the flood flows of the North Branch may be largely controlled by proper operation of the Scituate Reservoir which has a drainage area of about 93 square miles, a water surface of approximately 3400 acres and a capacity of nearly 5,000,000,000 cubic feet.

On the South Branch four reservoirs, with a total water surface of 1650 acres, have a combined capacity of 423,000,000 cubic feet. Flood conditions in this valley, which are troublesome at times of extreme freshets, could be controlled if the capacity of Flat River Reservoir were increased. It would be possible to raise the water level of this reservoir about 21 feet and to increase its water area from 1000 acres to 5800 acres and its capacity from 261,000,000 cubic feet to 4,000,000,000 cubic feet.

Storage on the Moshassuck River provides a fair control in normal freshet seasons. However, in 1886, 1927 and 1936 this storage was incapable of withholding sufficient water to avoid damage along the river below.

The Woonasquatucket River has storage of 236,000,000 cubic feet. Certain improvements at the reservoir dams would greatly relieve the flood conditions at points downstream. Flood conditions on the Potowomut River are not bad except in extreme high water. The construction of a reservoir in this valley for water supply for East Greenwich and Wickford would greatly reduce the flood hazard throughout the valley.

By and large the rivers of this basin cannot be classed as flood-producing streams and flood control is not of prime importance.

Power Even though these rivers are relatively small, they have a fair amount of natural fall which, for the most part, has been developed. The opportunities for additional development on these streams are few. The Pawcatuck River has numerous small developed sites, some of which are occupied by twine, woolen and other small plants. The U. S. Army Engineers' Report, published in 1929, listed 10 sites at which about 70 feet of fall were developed, with approximately 2500 horsepower installed wheel capacities, of which not more than 1500 horsepower were then in use. The amount of undeveloped power on the river and its tributaries is small and is of interest only to the local mill owners, as it is not suited to development for electricity.

The water power sites on the Pawtuxet River are fully occupied. Numerous storage reservoirs serve to regulate the river flow. The total fall at the various dams on the main river is 355 feet, on the South Branch, 164.7 feet, and on the North Branch, 112.0 feet. A reservoir on the South Branch could be built to facilitate river regulation and flood control. Another use of this reservoir, which may prove most important, would be as an additional source of water supply for metropolitan Providence.

The other rivers in the region have a few small power developments but cannot be considered as power streams.

Navigation Narragansett Bay, the chief waterway of Rhode Island, is extensively used by commercial, fishing and pleasure craft. The principal items of freight include petroleum products, coal, textiles and lumber; there is passenger service between the Port of Providence and the Port of New York; coastal fishermen secure large catches of shellfish in the Bay

and in the outside waters of the Atlantic Ocean; and the Bay affords a safe area and fine facilities for yachting. Newport Harbor is a famous yacht basin, and several yacht yards are located along the Bay, the most notable being the Herreshoff yard at Bristol, where most of the America's Cup defenders have been built.

Among the more important commercially navigable harbors and rivers are Providence River and Harbor; Pawtucket (Seekonk) and Taunton rivers; Fall River, Newport and Tiverton harbors.

The tonnage in these rivers and harbors in 1936 totaled close to 8,200,000 tons, valued at over three-quarters of a billion dollars, according to the 1937 Report of the U. S. Army Engineers. Smaller harbors along the Sound and at Block Island and Fishers Island handled, during the same year, about 86,000 tons with a value of $6,500,000. The following table gives the controlling depths and the 1936 tonnage and cargo values for these waters:

River or Harbor	Controlling Depth -- Ft.	1936 Commercial Traffic Tons	Value
Providence Harbor	17 - 30	5,453,870	631,236,198.
Fall River Harbor	30	2,023,058	131,172,344.
Taunton River	5 - 18	5,474	52,235.
Seekonk River	17	389,445	6,341,701.
Newport Harbor	13 - 18	91,858	16,241,950.
Bristol Harbor	16	2,125	108,284.
Warren River	12	18,736	250,258.
Tiverton Harbor	19 - 25	205,027	3,013,088.
Great Salt Pond (Block Island)	17 - 25	2,753	327,005.
Harbor of Refuge (Block Island)	15	6,238	1,144,100.
Pawcatuck River	9	23,092	269,644.
Stonington Harbor	11	7,270	200,534.
Mystic River	11½- 14½	777	52,500.
Hay (West) River (Fishers Island)	14	14,745	3,873,623.
Wickford Harbor	8 - 13	11,657	259,519.

Needed improvements in the navigation facilities of these harbors include deeper ship channels, enlarged anchorage areas and additional breakwaters. The city of Providence is preparing for a million-dollar improvement of its waterfront and will have ultimately a channel 35 feet deep at mean low tide. Newport Harbor can be improved by deepening of the main harbor and by dredging the southern part of the harbor to provide suitable anchorage for small craft. Enlargements of anchorage areas, with accompanying deepening of approach channels, are contemplated in Little Narragansett Bay, Pawtuxet Yacht Basin and Trimms Pond, on Block Island. The facilities of Sakonnet Harbor can be improved by the construction of a breakwater to afford shelter from northerly storms.

Drainage Fresh and salt marshes are abundant throughout this coastal area. The eastern shore and islands of Narragansett Bay have fewer inland swamps and somewhat less coastal marsh than the shores west of the Bay and along Block Island Sound. In southwestern Rhode Island, streams frequently rise in

swampy land pockets. Inland swamps predominate in the Pawcatuck watershed, in southern Rhode Island, where a topographical barrier prevents flow directly south into the Sound. South of this barrier, salt marshes occupy large areas.

Both permanent and seasonal residents of the basin have encouraged careful consideration of reclamation and mosquito control opportunities. Further investigation of the trends in recreational development are needed to secure more data than is now available concerning desirable locations for additional reclamation and mosquito control projects.

Erosion All the Rhode Island erosion problem areas, as identified by the Soil Conservation Service Reconnaissance Survey, are in this basin. Moderate sheet erosion, with the loss of one-fourth to three-fourths of the topsoil, accompanied by occasional gullying, was found to have affected over 20,000 acres. Moderate wind erosion affected over 19,000 acres in the vicinity of Narragansett and Warwick. However, this erosion is neither widespread nor severe in Rhode Island and is of importance only on the more rolling slopes. The eastern Connecticut coastal streams have little or no erosion. The siltage of channels in this region attests to the results of minor erosive action, even though this does not yet constitute a serious threat to the land.

Beach erosion around Block Island and along the western ocean front menaces shore property to the extent that in consecutive years beaches may be either attractive sandy strands or harsh gravelly shores. The U. S. Beach Erosion Board has estimated the cost of a study of Rhode Island beach conditions to ascertain what corrective measures should be undertaken to preserve this major recreational asset.

Recreation The coastal waters in the basin are renowned for all types of pleasure boating, while the Bay shores are equally famous as summer resorts. The principal deficiencies in recreational facilities are insufficient anchorages and harbors for pleasure craft and inadequate protection of resort property from the detrimental effects of obnoxious water conditions. In several localities domestic wastes, oil and other industrial offal so grossly pollute the waters that swimming in them endangers one's health.

Where this condition does not obtain, beaches have high recreational value because they are near large population centers. Because their value has been threatened by sea erosion, plans now under way should be put into effect to preserve all attractive beaches.

Wildlife in this vicinity comprises chiefly water fowl and salt water game fish. Extensive swamp lands in southwestern Rhode Island render improbable the stranding of migratory bird flights. The number of game fish has been reduced by polluted conditions in the Narragansett Bay vicinity, but may be increased if these conditions are alleviated.

TABLE III-D

SUMMARY OF STREAM FLOW RECORDS

THAMES-BLACKSTONE-TAUNTON BASINS

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
Thames River Basin						
Willimantic River						
near S. Coventry, Conn.	122	5	5,320	3	188	7,880
Shetucket River						
near Willimantic, Conn.	401	8	19,000	35	641	23,900
Hop River						
near Columbia, Conn.	76.5	4	2,680	6	127	33,000
Natchaug River						
at Willimantic, Conn.	170	6	7,830	5	270	14,200
Quinebaug River						
at Quinebaug, Conn.	157	5	7,190	2	256	9,400
at Putnam, Conn.	332	7	15,400	9.8	482	17,200
at Jewett City, Conn.	712	18	25,300	25	1,181	29,200
Moosup River						
at Moosup, Conn.	84	4	3,420	1.7	171	4,080
Yantic River						
at Yantic, Conn.	89	6	4,100	3.3	144	6,300
Blackstone River Basin						
Blackstone River						
at Worcester, Mass.	31.5	13	1,490	0.3	48.4	2,520
at Woonsocket, R.I.	416	7	14,000	13	637	15,000
Taunton River Basin						
Taunton River						
at State Farm, Mass.	260	7	3,100	9	447	3,100
Wading River						
near Norton, Mass.	42	11	978	0.3	77	1,030

TABLE IV

EXPLANATORY NOTES
Concerning the table of
SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

Column 1. Town or City. Municipalities, arranged alphabetically, where available information positively indicated the existence of an organized sewerage system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 Census.

Column 3. Population Served. Best available estimate of the persons served by an organized system.

Column 4. Discharge in thousand gallons per day. The best available estimate of the volume of sewage discharged.

Column 5. Treatment. Abbreviations, noted below, indicate the type of treatment applied to the domestic wastes.

Column 6. Chief sources of Industrial Wastes. The industries which commonly pollute streams are indicated by concise reference to the type of plant, product or raw material.

Symbols

--	No information available
(P)	Partial
(s)	Summer resort.
(S)	State Institution
(U)	College or University
Various	Several industries present with none clearly predominant.
Milk	Refers to pasteurizing, ice cream and dairy plants.
Fert.	Fertilizer factory.
Oil	Petroleum products; storage or distribution plants.
Gas	Illuminating gas manufacturing plant.
Cannery	Includes fish packing.

Im.	Imhoff Tank	A.	Aeration.
Sp.	Septic Tank	Cl.	Chlorination
SF.	Sand filtration.	St.	Settling
F.	Filtration.	Sc.	Screening (fine)
CP.	Cesspool	Br.	Barging sludge to sea.
Sl.	Sludge treatment.	Sm.	Sedimentation
AcSl.	Activated sludge plant.	Ir.	Irrigation

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments

TABLE IV-D

SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

THAMES RIVER

Town or City	Domestic Sewage: Population 1930	Population Served	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Griswold, Conn.	6,010	4,500	450	none	Textiles & printing
Groton	10,770	4,850	309	Sp.22%	Cannery & textiles
Killingly	8,852	2,500	800	none	--
Mansfield	3,349	2,000(U)	260	Sp.Sl.SF.	--
New London	29,640	29,190	2,430	Sp.Sl.Cl.4%	--
Norwich	32,438	24,500(S)	4,050	In.Sl.Cl.2% (1)	Cloth goods, gas and milk
Plainfield	8,027	1,600	130	Im.Sl.SF.	Textiles
Preston	3,928	2,500(S)	250	Sm.Sl.	--
Putnam	8,099	6,000	600	Sm.Sl.	Hats
Sprague	2,539	1,600	160	none	--
Stafford	5,949	2,500	250	Sc.	Woolens and yeast
Windham	13,773	11,000	1,250	Sc.	--

(1) New treatment plant under construction; Sm.Sl.Cl.

	Services				
Leicester, Mass.	4,445	--	115	Sm.SF.	Woolens
Southbridge	14,264	1,751	910	Sm.SF.	--
Webster	12,992	--	717	none	--

BLACKSTONE RIVER

Attleboro, Mass.	21,769	1,361	887	SF.	--
Hopedale	2,973	370	135	Sp.SF.(P)	Machinery
Millbury	6,957	--	833	none	Woolens
Northbridge	9,713	981	600	Sm.SF.	Paper, textiles and machinery.
North Attleboro	10,197	1,067	738	Sm.SF.	--
Worcester	195,311	--	19,630	Im.F.	Wire & woolens

	Served				
Central Falls, R.I.(1)	25,898	12,000	300	none	Cloth goods
East Providence	29,995	10,600	375	Sp.Cl.Sl.	Cloth goods and wire
Pawtucket (1)	77,149	50,600	2,000	none	Cloth goods & wire
Woonsocket	49,376	45,000	3,430	Ac.Sl.SF.	Cloth goods

(1) See Narragansett - Eastern Connecticut Coastals.

TAUNTON RIVER

Town or City	Domestic Sewage: Pop. 1930	No. of Services	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Bridgewater, Mass.	9,055	--	213	none	--
Brockton	63,797	8,810	2,889	Sm. F.	--
Fall River	115,274	--	5,902	none	--
Foxborough	5,347	--	--	SF. (P)	--
Middleborough	8,608	--	302	none	--
Taunton	37,355	--	3,735	none	--

NARRAGANSETT - EASTERN CONNECTICUT COASTAL

	Served				
East Lyme, Conn.	2,575	450	80	Im.Sl.SF.	Surgical goods
Waterford	4,742	180	18	Sm.Sl.Cl.	Paper
Bristol, R. I.	11,953	2,000	1,834	Sc.Sm.Sl.Cl.	Wire and woolen
Central Falls (1)	25,898	18,000	300	Im.F.Sm.	--
East Greenwich	3,666	2,000	112	Sp.SF.Sl.	Cloth and paper
Jamestown	1,599	1,000	35	none	--
Narragansett	1,258	1,000	63	none	--
Newport	27,612	25,000	100	none	--
Pawtucket (1)	77,149	22,000	1,000	Ac.Sl.	--
Providence	252,981	250,000	33,000	Ac.Sl.	Woolens
Warren	7,974	7,400	375	Sp.Cl.	Cloth & rubber
Westerly	10,997	10,000	1,083	Im.Sl.	Woolen

(1) See Blackstone Basin

EXPLANATORY NOTES
concerning tables of the
ORGANIZED WATER SUPPLY SYSTEMS

Column 1. Town or city. Municipalities, arranged alphabetically, where available information indicates the existence of an organized public or semi-public water supply system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 census.

Column 3. Population Served. Best available estimate of the persons served by an organized system (as for the year 1936).

Column 4. Consumption in thousand gallons per day. Best available estimate of the normal daily requirement.

Column 5. Sources of supply. The type of source drawn from is indicated by symbols:- R. for Reservoir, Pond or Lake; W. for Wells, either deep or shallow; Spr. for Spring; Str. for Streams.

Column 6. Watershed area in square miles. Best available estimate of the drainage area upon which the water supply is dependent.

Column 7. Capacity in millions of gallons. Best available estimate of the quantity of water stored by, or immediately available to, the municipal supply.

Column 8. Type of Treatment. Available information concerning the methods used to improve the quality of the water served.

SYMBOLS

(2), etc. Numerals enclosed in parentheses indicate the number of separate water supply systems which serve the municipality. Where there is only one system no symbol is necessary.

(S) Includes State institution
(T) Includes Summer population served
(U) Includes College or School
(s) Provides Summer service only
(a), (b), etc. Letters enclosed in parentheses link civil divisions served by the same water source:-
In column 3 and 4 they link municipalities where available information does not give the number served in each town.
In column 5 letter indicates that the civil division imports water.
In column 6 and 7 letter indicates that the civil division exports water.
Letters link municipalities within one state and basin; cross-references between basins or states appear in footnotes.

Symbols (continued)

A.	Aeration	K.	Activated carbon
Al.	Alum	L.	Lime
AlSl.	Aluminum sulphate	MF.	Mechanical filter
Am.	Ammonia	PF.	Pressure filter
AmSl.	Ammonium sulphate	pH.	Correction of reaction
AS.	Alum - Soda Ash	RF.	Rapid filter
CC.	Corrosive correction	S.	Soda ash
Cl.	Chlorine	SF.	Slow filter
Co.	Coagulation	Sm.	Sedimentation
CuSl.	Copper sulphite	SoCl.	Sodium hypochlorite
F.	Filter	St.	Storage of protective significance.
IR.	Iron removal		

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments
Annual Reports, Public Utilities Commissions

TABLE V-D

ORGANIZED WATER SUPPLY SYSTEMS

THAMES BASIN

Town or city	Pop. 1930	No. Services	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Dudley, Mass.	4,265	451	270	W.	--	--	none
Leicester (2)	4,445	560	--	W.	--	--	--
Oxford	3,943	707	220	W.	--	--	none
Southbridge	14,264	1,912	1,013	R.	5.8	270	A.SF.
Sturbridge	1,772	113	42	W.	--	--	none
Webster	12,992	1,693	717	W.	--	--	none
		Served					
Bozrah, Conn.	859	100	8	(a)	--	--	Cl.
Brooklyn	2,250	1,200	100	R.	1.3	91	Cl.
Coventry	1,554	600	36	R.	3.3	387	Cl.
Griswold	6,010	4,350	493	R.	1. (b)	90(b)	Cl.
Groton	10,770	6,700	758	Groton; Narr.-E.Conn. Basin		--	Cl.
Killingly (3)	8,352	6,000	424	R. & W.	3.3	125	Cl.84%
Lisbon	1,097	60	5	(b)	--	--	Cl.
Mansfield	3,349	100	8	(c)	--	--	F. Cl.
New London	29,640	30,500	2,522	Narr.-E. Conn. Basin		--	Cl.
Norwich (3)	32,438	32,400	4,340	R. & W.	13.7(a)	1400(a)	Cl.94%
Plainfield (2)	8,027	1,850	130	W. & Spr.	--	--	none
Putnam (2)	8,099	7,800	861	Str. & R.	38.5(d)	1(d)	Co.Sm.RF.93%;Cl.100%
Sprague (2)	2,539	1,750	122	R.	34.5	135	Co.RF.8%
Stafford	5,949	3,800	155	R.	6.	66	Cl.
Sterling	1,233	450	32	Spr.	--	--	none
Thompson (2)	4,999	3,300	171	W. & Spr.	--	--	none
Windham	13,773	12,400	852	R.	162.(c)	122(c)	F.Cl.
Woodstock	1,712	50	3	(d)	--	--	Co.Sm.RF.93%;Cl.100%

BLACKSTONE BASIN

Town or city	Pop. 1930	No. Services	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Attleborough, Mass.	21,769	4,090	1,239	W.	--	--	none
Auburn (2)	6,147	513	--	W. & (a)	--	--	none
Blackstone	4,674	--	--	(b)	--	--	--
Douglas	2,195	260	188	W.	--	--	none
Grafton (2)	7,030	534	168	W.	--	--	none
Hopedale	2,973	--	814(e)	(c)	--	--	--
Millbury (2)	6,957	990	833	W. & (a)	4	770	none
Northbridge	9,713	687	615	W.Spr. & R.	1.2	50	none
North Attleborough	10,197	1,755	809	W.	(d)	(d)	none
Plainville	1,583	--	86	(d)	--	--	--
Shrewsbury	6,910	1,242	285	W.	--	--	none
Sutton	2,147	84	--	W.	--	--	none
Uxbridge	6,285	878	236	Spr. & W.	--	--	none
Worcester	195,311	30,094	14,829	R.	30.2(a)	2028(a)	none

(b) Woonsocket, R. I. water supply.
(c) Milford, Mass. (See Massachusetts Coastal Basin)
(e) Includes Milford.

		Served					
Burrillville, R.I.(12)	7,677	7,515	375.3	W.Str.R.Spr.	3.0	.45	St.45%;Cl.90%
Central Falls	25,898	See Pawtucket (a)					
Cumberland (3)	10,304	350(a&b)	30(a&b)	R.(a&b)	1.	175	St.Cl.
East Providence(2)	29,995	See Pawtucket (a) and East Providence, Narr.-E. Conn. Coastal Basins					
Lincoln (3)	10,421	1,000(a&b)	60(a&b)	W.	--	.22	--
North Smithfield(4)	3,945	225(b)	105½(b)	W. & Str.(b)	90.	400.14	St.Co.pH.Sm.F.Cl.
Pawtucket	77,149	130,350(a)	9,400(a)	R.	27.8(a)	2,784 (a)	--
Woonsocket	49,376	58,000(b)	3,000(b)	R.	8.5(b)	1,140.5(b)	St.Cl.

TAUNTON BASIN

Town or city	Pop. 1930	No. Services	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Avon, Mass.	2,414	572	127	W.	—	—	none
Bridgewater	9,055	1,135	213	W.	—	—	none
Brockton	63,797	11,965	3,375	R.	7.5(a)	5,380(a)	—
East Bridgewater	3,591	920	154	(a)	—	—	—
Easton (3)	5,298	670	314	R.Spr.W. & (a)	2.7	5,200	F (P)
Fall River	115,274	13,059	5,902	R.	9.1	10,000	Cl.
Foxborough	5,347	—	—	W.	—	—	none
Mansfield	6,364	1,400	468	W.	—	—	none
Middleborough	8,608	1,349	302	W.	—	—	IR.A.Sm.SF.
Norton	2,737	395	152	W.	—	—	none
Somerset	5,398	904	178	W.	—	—	CC.
Taunton	37,355	7,122	2,735	R.	49	9,590	none
West Bridgewater	3,206	—	169	(a)	—	—	—
Whitman	7,638	1,848	279	(a)	—	—	—

NARRAGANSETT-EASTERN CONNECTICUT COASTAL BASINS

		Served					
Barrington, R.I.(2)	5,162	145(a)	5(a)	W. & (a)	—	.01	Cl.
Bristol (2)	11,953	25,040(a)	2,204(a)	R. & W.	37.5(a)	337.45(a)	St.Co.Sm.F.pH.Cl.
Charlestown (2)	1,118(T)	295	41	W.	—	.005	Cl.
Coventry (2)	6,430	See Cranston and West Warwick (b & c)			—	—	St.Cl.
Cranston (2)	42,911	8,000(d)	700(d)	R. & (d)	1.6(b)	285.(b)	Cl.
East Greenwich	3,666	5,000	460	W. & Str.	(e)	.38(e)	F.Cl.
East Providence(B)	29,995	18,000	1,800	R.	54.	421.	St.A.Co.K.Sm;A.pH. F.Cl.)
Exeter	1,314	760	20	W.	—	.1	—
Hopkinton	2,823	60	5	W.	—	.01	Cl.
Jamestown	1,599(T)	3,200	350	R.	1.2	57.86	St.Co.Sm.F.Cl.
Johnston	9,357	See Providence (d)					
Little Compton	1,382	200	—	W.	—	.01	—

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Middletown, R. I.	2,499	See Newport (f)					
Narragansett (4)	1,258(T)	5,100	19.3	Spr. & W.	--	.0115	--
Newport	27,612(T)	27,900(f)	4,250 (f)	R.	7.9(f)	1591. (f)	St.Am.Co.K.A.Sm.F. pH.Cl.)
New Shoreham	1,029	300	--	W. & R.	.2	.02	St.
N. Kingstown(2)	4,279(T)	425(s)	10	W.	--	.0005	--
N. Providence(3)	11,104	700(d&g)	43	W.(d) & (g)	--	--	--
Portsmouth (3)	2,969(T)	1,565	37.8	W. & Str.	--	.0257	--
Providence	252,981	336,900(d)	29,000(d)	R.	92.8(d)	40,572(d)	St.Co.A.pH.Sm.F.Cl.
Richmond	1,535	150	7	W.	--	.02	--
Scituate (2)	2,292	25(b)	(b)	W. & (b)	--	.001	--
Smithfield (3)	3,967	1,300	72	W. & Spr.	--	.04075	Cl.92%
S. Kingstown(4)	6,010	9,320(U)	814	Str. Spr. W.	2.	.4906	St.Co.F.pH.Cl.86%
Tiverton	4,578	2,400	70	W.	--	1.05	--
Warren (7)	7,974(T)	729(a)	49⅓(a)	W. & (a)	--	.0274	--
Warwick(7)	23,196	320(b,c,d&e)	2(b,c,d&e)	W.(b,c,d&e)	--	.0015	--
Westerly (2)	10,997	16,900	920	W.	--	1.52	--
West Warwick(2)	17,696	12,000(b&c)	900(b&c)	R. & (b)	.6(c)	400.475(c)	St.Cl.
East Lyme,Conn.(2)	2,575	695	36	W.	--	--	none
Groton (A)	10,770(T)	1,000	23	R.	9	--	Cl.
Old Lyme (5)	1,313(T)	4,200	210	W.	--	--	none
Stonington (3)	11,025	9,575	990	R. & W.	6.7	120	A.Co.Sm.RF.Cl.81%
Waterford (2)	4,742	230	16	W. & New London; Thames Basin		--	Cl.50%
			Exported				
New London	(See Thames Basin)			R.	7.2	1,054	Cl.

(B) East Providence, Blackstone Basin.
(g) Pawtucket, Narragansett-Eastern Connecticut Coastal Basin.

(A) Groton, Thames Basin

TABLE VI-D

EXISTING WATER POWER - TAUNTON - BLACKSTONE - THAMES BASINS

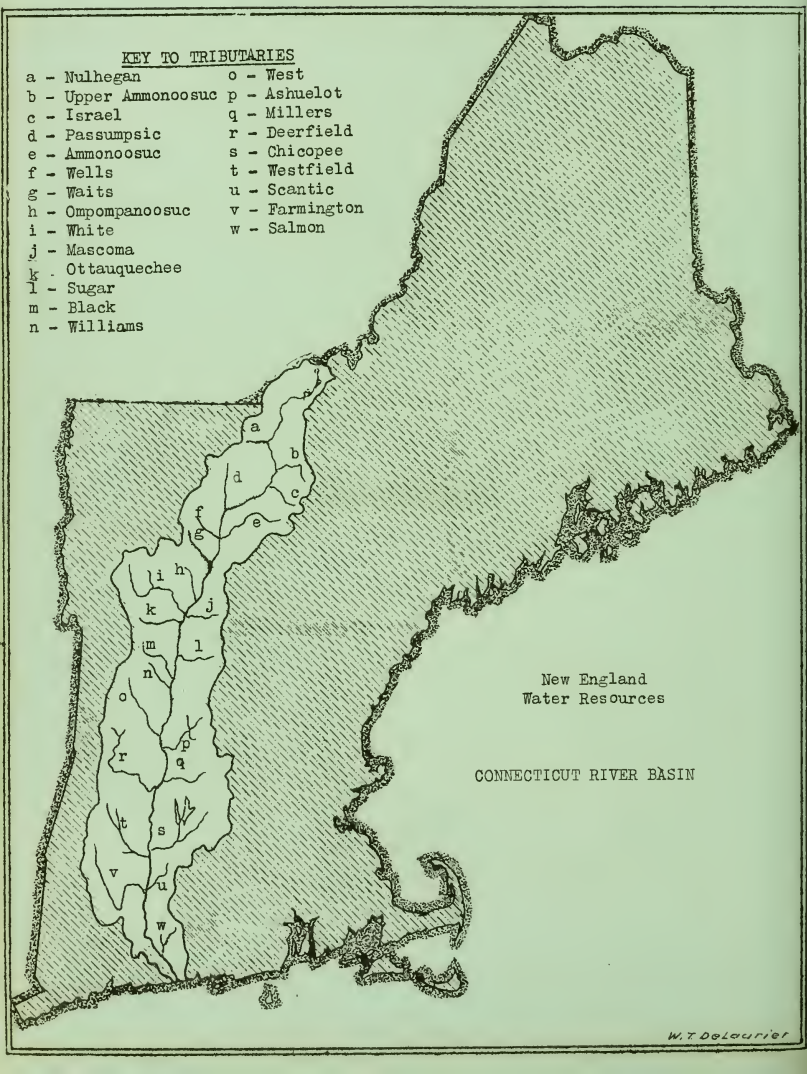
RIVER	NO. OF PLANTS IN Ms.	R.I.	Ct.	CAPACITY OF PLANTS OF over 10,000 HP.	1,000 to 9,990 HP.	under 1,000 HP.	CAPACITY USED FOR Utility	Mfg.	TOTAL CAPACITY Horse-power
TAUNTON	5	0	0	0	0	850	160	690	850
Main Stream	3	0	0	0	0	440	0	440	440
Others	2	0	0	0	0	410	160	250	410
BLACKSTONE	24	25	0	0	6,380	14,795	2,700	18,475	21,175
Main Stream	13	16	0	0	6,380	9,270	2,700	12,950	15,650
Mumford	8	0	0	0	0	1,925	0	1,925	1,925
Branch	0	6	0	0	0	1,640	0	1,640	1,640
Others	3	3	0	0	0	1,960	0	1,960	1,960
THAMES	23	0	56	0	27,735	20,076	13,554	34,257	47,811
Shetucket	0	0	11	0	11,285	1,165	5,695	6,755	12,450
Willimantic	0	0	10	0	1,210	3,290	1,210	3,290	4,500
Quinebaug	9	0	11	0	11,730	6,107	5,569	12,268	17,837
French	14	0	5	0	2,360	3,655	1,080	4,935	6,015
Five Mile	0	0	5	0	0	1,445	0	1,445	1,445
Moosup	0	0	5	0	0	1,210	0	1,210	1,210
Pachaug	0	0	4	0	0	2,325	0	2,325	2,325
Yantic	0	0	5	0	1,150	879	0	2,029	2,029
NARRAGANSETT BAY AND EAST. CONN. COASTALS	0	26	0	0	8,220	7,010	2,500	12,730	15,230
Woonasquatucket		4	0	0	0	700	0	700	700
Pawtuxet	0	3	0	0	2,100	340	0	2,440	2,440
N. Branch	0	6	0	0	2,500	2,080	2,500	2,080	4,580
S. Branch	0	7	0	0	3,620	2,490	0	6,110	6,110
Pawcatuck	0	6	0	0	0	1,400	0	1,400	1,400
GRAND TOTAL	PLANTS 159			0	42,335	42,731	18,914	66,152	85,066

TABLE VII-D: EXISTING STORAGE

THAMES-BLACKSTONE-TAUNTON BASINS

	Drainage Area Sq.Mi.	Water Surface Sq.Mi.	Storage Capacity Acre-feet	Storage Equivalent Inches of Runoff
Taunton River				
Quittacus Ponds (W.S.)	12.9	2.5	16,800	24.6
Others			14,370	
Estimated Total	516		32,000	1.2
Blackstone River				
Lake Quinsigamond	25.7	1.4	5,160	3.8
Others, Massachusetts			17,350	
" , Rhode Island		1.8	20,000	
Estimated Total	540		42,500	1.5
Narragansett-Eastern Connecticut Coastals				
Pawtuxet Basin				
Scituate Reservoir (W.S.)	93.	5.3	113,600	23.0
Others		2.6	9,710	
Woonasquatucket Basin	52	1.4	5,417	2.0
Estimated Totals	1,050		130,000	2.3
Thames Basin				
Stiles Reservoir	4.	0.6	4,610	21.7
So. Charlton Reservoir	8.3	0.4	3,300	8.1
Lake Chaubunagungamaug	9.9	1.9	4,750	9.0
Deep River Reservoir (W.S.)	8.5	0.2	1,180	2.6
Fairview Reservoir (W.S.)			1,380	

CONNECTICUT BASIN


KEY TO TRIBUTARIES
a - Nulhegan
b - Upper Ammonoosuc
c - Israel
d - Passumpsic
e - Ammonoosuc
f - Wells
g - Waits
h - Ompompanoosuc
i - White
j - Mascoma
k - Ottauquechee
l - Sugar
m - Black
n - Williams
o - West
p - Ashuelot
q - Millers
r - Deerfield
s - Chicopee
t - Westfield
u - Scantic
v - Farmington
w - Salmon
New England
Water Resources
CONNECTICUT RIVER BASIN
W.T. DeLaurier

CONNECTICUT BASIN

GENERAL DESCRIPTION

The Connecticut has the largest basin in New England. Nearly 300 miles long and, at the maximum, 62 miles wide, it drains parts of four states and Canada. The drainage areas are approximately as follows:

New Hampshire	3,110	sq. mi.
Vermont	3,960	" "
Massachusetts	2,710	" "
Connecticut	1,425	" "
Total in New England	11,205	" "
Canada (Quebec Province)	115	" "
Total area of basin	11,320	" "

The Connecticut basin gives a cross-section of most of the varied topographic conditions in New England, except that it has very little of the rolling lake-studded topography typical of parts of Maine. The extreme headwaters rise in irregular and mountainous country in northern New Hampshire; then the river flows generally south between the rugged ridges of the White and Green Mountains with their narrow steep valleys and ragged peaks--the highest in New England; crossing central Massachusetts and northern Connecticut, it flows through wide, fertile bottomlands between the well-defined ridges of the Berkshire-Litchfield Hills on the west and the lower, rolling hills that form the eastern watershed; in central Connecticut the river turns abruptly southeast and flows through a narrow valley in irregular country out across fairly level, swampy lands into Long Island Sound.

The total length of the river is about 400 miles, of which 240 miles form the boundary line between the states of New Hampshire and Vermont (west bank at mean low water). In the 340 miles between First Connecticut Lake and tidewater, at Hartford, the total fall is 1643 feet, somewhat over two-fifths of which is developed.

The rock formation of that part of the basin which lies in New Hampshire and Vermont is almost entirely granite, but the structure of the valley's inner rim in southern Massachusetts and Connecticut is largely sandstone and shale with frequent thrusts of traprock. Soils are in general sandy and stony, except for the fertile, comparatively stone-free sandy loams of the wide Massachusetts-Connecticut part of the valley.

More than 25% of the basin is in cleared farm land, most of which is in the narrow valleys and steep side slopes of the northern tributaries or in the broad level valley of the lower main stream. An eighth of the total area is in crop-land, and of this the tobacco and onion region of Massachusetts and Connecticut accounts for a large proportion. The higher parts of the basin are largely wooded, with conifers predominating in the north and mixed hardwoods in the south, especially the southeast. Little of the timber is virgin growth, and many parts of the basin are covered with poor growth of naturally reseeding stock.

The annual precipitation varies considerably in the basin. In the northern part of the basin it averages from 36 to 40 inches, with a somewhat heavier fall in the summer months; about one-fourth of the total precipitation is snow. In Connecticut and Massachusetts the average is from 40 to 48 inches, evenly distributed throughout the year, and with much less snow. Average temperatures vary between 60° and 68° in summer, and between 14° and 30° in winter.

Discharge records for the Connecticut River have been obtained by the U. S. Geological Survey in cooperation with the states of Vermont, New Hampshire, Massachusetts, and Connecticut at numerous gaging stations located on the main river and its tributaries.

Detailed data for these 44 stations, 8 on the Connecticut River and 36 on its tributaries, may be found in Water Supply Papers of the U. S. Geological Survey.

The figures in Table III-E are summarized from unpublished records in the offices of the District Engineers at Boston, Mass., and Hartford, Conn., as well as from the Survey's Water Supply Papers covering Part I,-"North Atlantic Slope Basins."

Hydrographs denoting the monthly average runoff during the last 15 years of record are shown on Chart 11 for:

Connecticut River at White River Junction, Vermont
Connecticut River at Montague City, Massachusetts
Connecticut River at Thompsonville, Connecticut

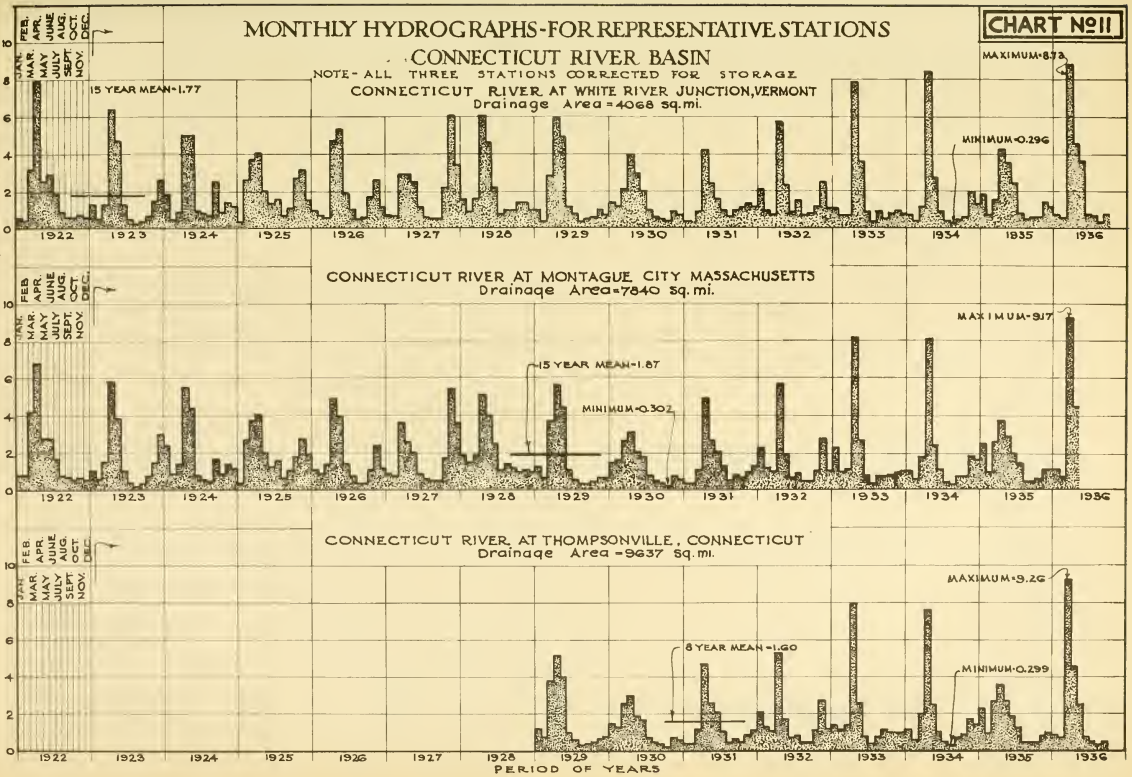
The station at Thompsonville, established in July, 1928, has a hydrograph drawn up for the past 8 years.

The mean annual discharge for the period of record at each of the stations is, in cubic feet per second per square mile:

White River Junction	(drainage area 4068 sq.mi.)	1.80
Montague City	(drainage area 7840 sq. mi.)	1.73
Thompsonville	(drainage area 9637 sq. mi.)	1.60

The Connecticut River system includes 23 important tributaries, of which 10 are in Vermont, 6 in New Hampshire, 2 in Massachusetts, one in Connecticut; the remaining 4 are inter-state streams. All that part of the drainage area that is more than 15 miles from the main stream is drained by some one of these tributaries. The following table summarizes pertinent information about them:

Tributary	State	Course (direction of flow)	Length (miles)	Point of entry (miles above mouth)	Drainage Area (sq.mi.)
Nulhegan	Vermont	E	15	345	151
Upper Ammonoosuc	New Hampshire	W	35	325	260
Israel	New Hampshire	NW	15	312	130
Passumpsic	Vermont	S	40	279	507
Ammonoosuc	New Hampshire	W	45	266	402
Wells	Vermont	SE	20	266	99


MONTHLY HYDROGRAPHS-FOR REPRESENTATIVE STATIONS
CHART No 11
CONNECTICUT RIVER BASIN
NOTE- ALL THREE STATIONS CORRECTED FOR STORAGE
CONNECTICUT RIVER AT WHITE RIVER JUNCTION, VERMONT
Drainage Area = 4068 sq. mi.
15 YEAR MEAN-1.77
MAXIMUM-8.73
MINIMUM-0.296
CONNECTICUT RIVER AT MONTAGUE CITY MASSACHUSETTS
Drainage Area = 7840 sq. mi.
15 YEAR MEAN-1.87
MAXIMUM-9.17
MINIMUM-0.307
CONNECTICUT RIVER AT THOMPSONVILLE, CONNECTICUT
Drainage Area = 9637 sq. mi.
6 YEAR MEAN-1.60
MAXIMUM-9.26
MINIMUM-0.299
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936
DISCHARGE - CUBIC FEET PER SECOND PER SQUARE MILE
PERIOD OF YEARS

Tributary	State	Course (direction of flow)	Length (miles)	Point of entry (miles above mouth)	Drainage Area (sq.mi.)
Waits	Vermont	SE	20	247	156
Ompompanoosuc	Vermont	SE	20	224	136
White	Vermont	SE	50	215	710
Mascoma	New Hampshire	W	30	214	195
Ottauquechee	Vermont	E	30	210	223
Sugar	New Hampshire	W	30	195	274
Black	Vermont	SE	40	183	202
Williams	Vermont	SE	20	176	117
West	Vermont	SE	45	149	423
Ashuelot	New Hampshire	SW	45	140	420
Millers	N.H. - Mass.	W	40	126	393
Deerfield	Vt. - Mass.	S & E	70	119	665
Chicopee	Massachusetts	SW	45	80	724
Westfield	Massachusetts	SE	60	75	520
Scantic	Mass. - Conn.	SW	25	60	113
Farmington	Mass. - Conn.	S,NE,E	75	57	613
Salmon	Connecticut	SW	25	18	152

HUMAN OCCUPANCY

Population In 1930 this watershed had a population, over two-thirds urban, of 1,230,000, more than one-seventh of the total population of New England. That part of the basin lying in Connecticut and Massachusetts, about one-third of the total area, contains four-fifths of the entire population, and has a density of 247 per square mile, as contrasted to the density of only 30 per square mile in the New Hampshire and Vermont sections.

The southern portion contains prominent metropolitan and industrial districts which owe their existence to the expansion of active industrial cities; the more important of these cities are: Hartford (pop., 164,072) and New Britain (pop., 68,128) in Connecticut; Springfield (pop., 149,900) and Holyoke (pop., 56,537) in Massachusetts. In addition there are, throughout the basin, numerous key manufacturing cities and towns:

Connecticut		Massachusetts		New Hampshire	
Bristol	28,451	Chicopee	43,930	Keene	13,794
W. Hartford	24,941	Northampton	24,381	Claremont	12,377
Middletown	24,554	Westfield	19,775		
Manchester	21,973	Gardner	19,399	Vermont	
E. Hartford	17,125	W.Springfield	16,684		
Enfield	13,404	Greenfield	15,500	Brattleboro	9,816
		Easthampton	11,323	St. Johnsbury	9,696
		Athol	10,677	Springfield	6,955

The population of the Connecticut basin increased 135,000, or 12.3%, between 1920 and 1930, 2% more than the New England region as a whole. Massachusetts and Connecticut accounted for 128,000 of this increase. Map 7 shows the cities and towns that gained or lost in this period. It will be noted that the heaviest gains were principally in the metropolitan districts

of Hartford and Springfield-Holyoke. Those New Hampshire and Vermont communities which increased in population are mostly along the Connecticut river. Trends indicate that the future population growth in this basin will be almost entirely in the southern portion, in areas surrounding the industrial centers. Judging from past changes, any increase in population in the northern region will probably be confined to a few manufacturing towns and will be of relatively small volume.

Thompson and Whelpton have estimated that the population growth of New England in the next twenty-five years, assuming internal migration similar to that of the 1920-30 decade, will be about 10% over the population of 1930. This prediction indicates a material slowing-down in the rate of growth. As the Connecticut is such a typical cross-section of New England, it can well be assumed that this prediction applies equally well to the Valley and to all New England.

Agriculture This basin contains some of the most fertile farm lands of New England, especially along the lower Connecticut. Farming in the river valleys brings in a large revenue, estimated in 1929 at about $65,000,000. Dairy products and field crops are the leading commodities produced north of the State of Connecticut; the southern part of the valley contains highly productive soil especially suited to the growing of tobacco, which has accounted for a large part of farm income in Connecticut. Poultry production, dairying, market gardening, and part-time farming in the industrial localities are important activities.

Although tobacco cultivation has formerly contributed heavily to farm revenue, recently it has become less active on account of changing market conditions. This situation makes it necessary to develop other crops which can be profitably cultivated on the high-priced tobacco lands. This, and other factors, such as the fine quality of soil and the ready access to large markets, have created a tendency toward specialized farming in the lower Connecticut valley. Of relatively great importance in the northern part of the basin is the farm woodlot, which now yields an appreciable portion of farm revenue, and which, as conditions improve, will become even more profitable if managed to produce higher quality timber.

Industry The principal industrial area is that part of the basin lying in southern Massachusetts and central Connecticut. Manufacturing activities cover a wide range, including the production of metals, machinery, tools, textiles, paper, and many other lines. Hartford, New Britain and several other cities of the region are identified with the production of high-grade machinery. Holyoke is noted for the manufacture of fine papers, and Springfield for a wide variety of products. Those manufactures requiring highly skilled labor are typical of this section. The total production value for the entire Connecticut basin in 1929 was approximately one billion dollars, nearly one-sixth of the total for New England. Due to the high degree of diversification of its industries, this region suffered less in manufacturing losses during the depression years than other sections of New England. Because of this wide diversification and because of the way in which industries in this valley weathered the depression, it is probable that industrial growth will continue at the same rate as in the past.

Mining Mineral deposits in wide variety are found in this valley. In Vermont and New Hampshire granite and talc quarries have a substantial output. In Cheshire and Grafton counties deposits of mica and feldspar are worked commercially. Copper veins in the northern basin are reported as having productive possibilities, although none have to any extent been mined on a commercial basis.

Future developments in the field of mining will probably be in proportion to the market demand for the minerals now produced.

Lumbering In the northern part there is heavy forest growth of spruce, fir, beech, birch and maple; in the south, white pine and hardwood stands are interspersed with pasture and farm land, except on the ridges of the Berkshires, which are covered with second growth hardwoods and conifers. Lumbering was for many years a major industry in the Vermont and New Hampshire sections but, with the depletion of the forests, it has declined to a fraction of its former volume. However, forests are still an important asset, and should, in the future, play a vital part in the economic life of the region.

The future of the lumber industry depends upon sound and enlightened management of forests, both public and private. Signs of depletion of forest assets are evident in the northern section, where the prevailing growth, spruce, is cut for pulpwood. White pine has possibilities of increasing value. The available quantities of hardwood indicate that there is a field for more wood-using industries. Further development of the national and state forests, particularly in northern New Hampshire, will lead to increased production of lumber.

Recreation The mountainous rim of the Connecticut River basin provides excellent sites for sporting and recreation centers. Many summer homes and resorts are located along the rims of the basin which extends from the Canadian line southward through four states to Long Island Sound. Since many of the most critical rural problems of New England are to be found in this same area, the importance of recreation as the most economical form of land-use here is demonstrated.

The federal and state governments have acquired large areas which are or will be devoted to recreation, but the need for additional facilities is great, particularly in the southern end of the basin. Almost all sizeable lakes and ponds in the lower basin have been set aside as public water supplies; hence, there is a dearth of facilities for water recreation. The population in the concentrated centers in and near the lower basin is thereby forced to go for recreation to the already overcrowded shore regions.

The main stream, below Springfield, is now so polluted that the great potential recreational assets of this river are almost entirely wasted. In spite of the pollution, however, there is a moderate amount of pleasure boating on the river below Hartford.

There are many opportunities for further utilization of recreational possibilities in the basin. Many large areas of water that are now reserved for public water supply should be made available for boating and fishing. From the standpoint of recreation, a comprehensive flood control program for the Connecticut can, in some part, be justified by the fact that stream regulation would make possible recreational development along the main stream

where floods and extreme low water flows make such development impractical at present.

Transportation Commercial navigation on the Connecticut River is confined at present to the fifty-two miles between Hartford and the mouth of the river, while the dam at Holyoke, thirty-four miles above Hartford, is the head of any possible navigation. Extensive improvements of the channel below Hartford have been and are being made by the U. S. Army Engineers; the present project, authorized in 1935, provides for a channel 150 ft, wide and 15 ft. deep at mean low water throughout the navigable part of the river.

The development of roads to connect the towns on the Connecticut River with the coastal settlements began in early colonial days. Later roads were pushed up the valley to reach the northern settlements. Today, these early roads form the foundation of a system of highways interconnecting all the important cities and towns in the basin, but many of these highways are inadequate to meet present traffic needs, and re-developments or new developments in many sections have been proposed by state agencies and by the New England Regional Planning Commission.

Adequate railroad facilities are provided in practically all parts of the basin, not only by lines of New England railroad systems but also, in the northern section, by those of the Canadian National and Canadian Pacific Railways.

The Connecticut valley is crossed by the existing airways from Boston to New York, Boston to Albany, and Boston to Burlington. However, the only scheduled air transport stop is at Hartford, Connecticut. Development of an airway up the valley from Hartford to White River Junction and Whitefield, and improvement of landing facilities in many places, particularly at Springfield, are desirable if the population and recreation centers of the Connecticut basin are to have adequate air service.

WATER USE AND CONTROL

Pollution The percentage of towns in the basin that have collecting sewers is far less than the percentage of those that have water supplies. Of the few sewage treatment works in the basin, the majority are in the state of Connecticut, where the State Water Commission has formulated a practical construction program. When new works now being built shall be in operation, domestic pollution by Connecticut communities will be greatly reduced. Massachusetts should take similar steps to rectify present polluted conditions in its part of the Connecticut River, and the Department of Public Health is required to report on this matter to the 1935 Legislature.

Much of the Vermont portion of the basin is of recreational value, and a large section is included in the National Forest Purchase Area. Probably this area will never present acute water supply or pollution problems. There are a few woolen and pulp and paper mills and creameries which discharge their wastes into the main stream and its tributaries.

There are no chemical analyses available for this portion of the Connecticut River but, considering the dilution factor, the length and other characteristics of the river, and the tributary population both in Vermont and New Hampshire, the sanitary condition, except in scattered minor instances, is probably satisfactory as far as the Massachusetts boundary.

The three most important tributary streams are the Passumpsic, White and Black rivers. The Passumpsic River has a drainage area of 423 square miles at the gaging station at Passumpsic; summer flows in cubic feet per second at that point are listed as follows ("low" flow is 24-hr. minimum):

	1934		1935		1936	
	Mean	Low	Mean	Low	Mean	Low
July	190	91	375	181	182	102
August	122	40	251	105	134	71
September	270	75	302	89	244	122

The principal sources of pollution are from sewage and industrial waste at Lyndon and St. Johnsbury. The latter town has a population of nearly 10,000. The low river flows indicate that for short periods of time offensive conditions may obtain near St. Johnsbury but in general dilution is adequate.

The White River has a drainage area of 690 square miles at the gaging station at West Hartford; here summer flows in cubic feet per second are:

	1934		1935		1936	
	Mean	Low	Mean	Low	Mean	Low
July	150	84	765	428	374	180
August	106	71	301	163	295	129
September	221	68	321	150	517	254

There are scattered sources of pollution, but dilution is probably sufficient to prevent objectionable conditions except in a few localities.

The Black River has an area of 158 square miles at the gaging station at North Springfield; summer flows in cubic feet per second are:

	1934		1935		1936	
	Mean	Low	Mean	Low	Mean	Low
July	64.2	29	279	84	43.8	24
August	37.7	21	76.7	42	41.2	22
September	90.6	22	85.7	31	42.5	17

The principal towns in the Black River basin are Ludlow, Cavendish and Springfield with populations of 2,305, 1,418 and 6,955, respectively. Cavendish has no sewer system, but industrial wastes are discharged at all of these towns. During the seven-year period for which records are available, a low flow of 11 cubic feet per second has been observed. Obviously, sewage treatment is needed during such low flow periods, despite the generally adequate mean flows.

Partial treatment of sewage from all the larger towns would lessen the burden carried by the tributaries and the main stream, especially during dry periods. The need for treatment works could be better determined if the results of chemical analyses and bacterial examinations of river water were available.

The following towns in New Hampshire are not listed as having sewer systems:

Swanzey	2066	Sunapee	1040
Marlboro	1508	Plainfield	858
Canaan	1301	Lyme	830
Troy	1267	Bath	785
Stewartstown	1148	Franconia	514

No town which has a sewer system is without a water supply. There is one sewage treatment plant in the New Hampshire section of the basin: Keene has Imhoff tanks the effluent from which is discharged into the Ashuelot River.

The Connecticut River and its tributaries receive little pollution above the Lower Ammonoosuc River. Studies of pollution on the latter, made in 1932 by Metcalf & Eddy, Boston, showed that there was high bacterial contamination in portions of the river above Bethlehem, due primarily to the discharge of raw sewage from several hotels. The population is largest and the greatest use is made of recreational areas at the time when river flows are the lowest. The study recommends local treatment of sewage at each hotel.

The drainage area of the river at Pierce Bridge, in Bethlehem, is 90 square miles. The following summer flows at this point are computed from runoff data in the Pemigewasset River (figures represent flow in cubic feet per second):

	July	August	September
Mean	163	124	174
Minimum	17.6	12.5	9.9

The mean flow is entirely adequate for proper disposal by dilution, but during very dry weather objectionable conditions exist. Below Bethlehem domestic sewage and/or industrial waste is discharged at Littleton, Lisbon, Landaff, Bath, and Woodsville.

Other tributaries which warrant consideration are the Mascoma, Sugar and Ashuelot Rivers, on whose banks are located (according to the 1936 New Hampshire State Planning Board Report) 8%, 18% and 41%, respectively, of the industrial plants in the New Hampshire part of the basin. The Mascoma has a drainage area of 195 square miles above its mouth at Lebanon. Raw sewage, septic tank effluent and textile wastes are discharged at Enfield; raw sewage and textile wastes are added at Lebanon, (pop., 7073). Pollution entering the Mascoma is so serious that the flow required to maintain a tolerable condition in the river is about 42 cubic feet per second, on .22 cubic feet per second per square mile. A flow at least this high is observed about 99% of the time at the gaging station at Mascoma, where the drainage area is 133 square miles. However, Mascoma Lake is at present polluted by mixed wastes to such extent that it is unsatisfactory, though not useless for recreation.

The Sugar River receives mixed wastes from Sunapee, Newport and Claremont, which have a total population of 18,076. The sources of these wastes are as follows:

Sunapee	-- one woolen company
Newport	-- sewer system, one shoe company and two woolen companies
Claremont	-- sewer system, two woolen companies and two paper companies

Assuming no pollution upstream, Claremont (pop., 12,377) would normally require a dilution flow of about 72 cubic feet per second, or 0.26 cubic feet per second per square mile from the whole drainage basin, to prevent objectionable conditions. The actual flow is less than this amount about 7% of the time.

The upper reaches of the Ashuelot River are comparatively clean, but the concentration of population and industry in the lower reaches gives rise to pollution problems here. Keene, the largest New Hampshire community in the Connecticut basin, treats its sewage by settling in Imhoff tanks. However, the many industrial plants along the Ashuelot discharge untreated wastes directly into the river. Of all the minor rivers in the New Hampshire part of the basin, conditions in the Ashuelot call most strongly for further investigation.

The principal towns in the Massachusetts part of the Connecticut basin without organized sewerage are:

1930 Population

		E. Longmeadow	3327
Monson	4918*	Belchertown	3139*
Warren	3735	Wilbraham	2719
Barre	3510	Hadley	2682

* State Hospital has sewers and treatment

In addition there are 13 towns of over 1000 population which have water supply systems but no sewerage. There are no sewer systems in those towns which do not have water supplies. The majority of towns with sewer systems discharge raw sewage into adjacent water courses, but Gardner, Easthampton, Spencer, Winchendon, Amherst and North Brookfield have treatment plants. (See Table IV-E).

The principal tributaries joining the Connecticut River are the Westfield, Deerfield, Chicopee and Millers rivers. Minor streams with significant pollution problems are the Mill and Manhan rivers.

The 1935 Massachusetts Department of Public Health Report stated that analyses of Millers River "showed an increase in pollution in this stream below Gardner". This condition would be greatly improved if Athol and Orange had sewage treatment works. Large amounts of industrial waste which add to the burden of the river at these points might well be given partial treatment.

The waters in the upper reaches of the Deerfield River are essentially pure, due in part to the protection afforded the Massachusetts headwaters by large areas of State Forest. The extreme lower reaches are polluted from mixed wastes discharged at Greenfield and Deerfield. The following is quoted from Massachusetts House Document #1200, 1937: "Other streams, like the Deerfield River, are, except for very few industries, comparatively free from pollution and excellent for all forms of recreation."

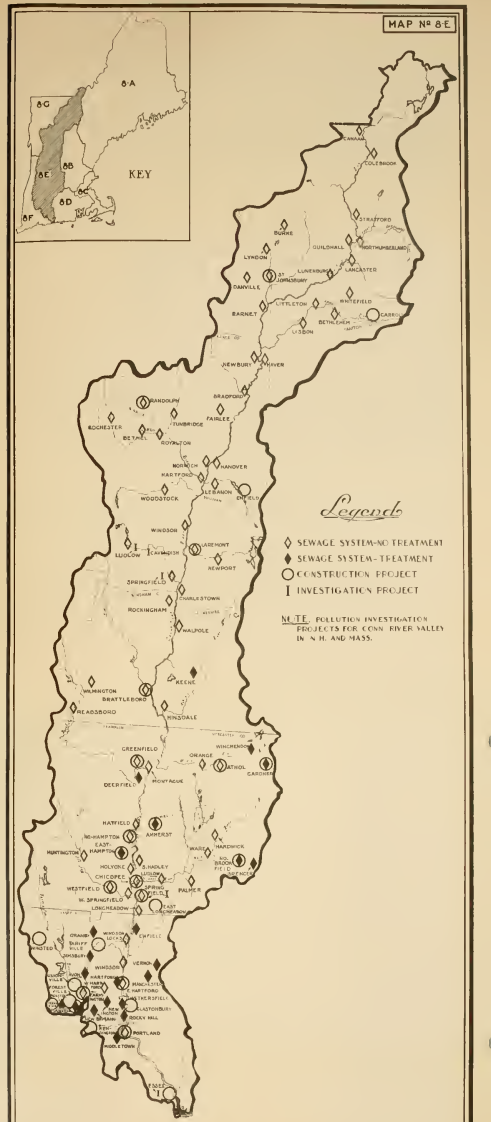
The Chicopee River is formed by the Swift, Quaboag and Ware rivers. In the future the waters of the Swift will be in part diverted for the use of the Boston Metropolitan Water District. The Quaboag receives mixed wastes from organized sewer systems in Palmer and North Brookfield. Sand filter effluent is added to its tributary, the Seven-Mile River, in Spencer. Pollution conditions on the Ware and Swift rivers will probably not be aggravated by diversion of water for the Metropolitan Boston Supply as restrictions on the taking of water protect the low water flows.

Because the headwaters on the Westfield River are in a sparsely populated area, much of which is in State Forest or is controlled by the Springfield Water Supply, this river is comparatively free from pollution above Westfield. However, at that point and at West Springfield large quantities of domestic sewage and industrial waste are discharged into the stream.

Conditions in the Mill and Manhan rivers are made exceedingly objectionable by the discharge of domestic sewage and industrial waste at Northampton and Easthampton.

The pollution of the Connecticut River in Massachusetts can be attributed chiefly to:

1 - Pollution which enters the main stream from the Massachusetts tributaries;
2 - General lack of treatment facilities in the sewer systems of the basin in Massachusetts;
3 - Untreated industrial waste from large manufactories along the main stream in Massachusetts, particularly at Springfield and Holyoke.



New England Water Resources

Sewage and Pollution

Connecticut Basin

DEC. 1 1937

SCALE

0 5 0 5 10 24 32

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

The Massachusetts Legislature has several times had before it the matter of an investigation of the sanitary condition of the Connecticut River; Chapter 66 of the Resolves of 1937 directs the Department of Public Health to cooperate with the Federal Works Progress Administration in assembling data pertaining to the pollution of the river. That Department is now engaged in complying with this resolve. The amount of dissolved oxygen in the Connecticut River in Massachusetts was reduced during August, 1937 to 4. parts per million; this indicates that the stream receives considerable pollution, although the nuisance stage has not yet been reached. The Massachusetts situation can be rectified only by steps similar to those already taken by Connecticut in the matter of sewage treatment. Detailed studies are needed to determine whether local or district treatment is needed. The findings should form the basis of a program of control.

The following towns in the Connecticut portion of the basin are without public sewerage systems:

Glastonbury	5783	
Berlin	4875	
Newington	4572	(2 institutions have sewage treatment works)
Cromwell	2814	
Essex	2777	
Saybrook	2381	
Ellington	2253	

There are also nine towns with populations from 1000 to 2000 which have no public sewerage.

Since the appointment, in 1925, of the Connecticut State Water Commission, progressive steps towards pollution control have been taken in that state. The Hartford Metropolitan District sewage treatment plant, soon to be completed, will include bar screens, grit chamber, settling tanks and vacuum filters; this plant will operate except during high river flows. Treatment plants are also being built or have recently been completed at Enfield, Middletown, New Britain, and Tariffville, in Simsbury. The New Britain plant employs a modified chemical treatment process.

Table IV-E shows that there are 9 Connecticut towns or cities in the Connecticut River basin which have sewage treatment plants; these nine towns, plus two state institutions, account for about 34% of the basin population; when other works mentioned (Enfield and Hartford) shall be completed, the sewage discharged by 70% of the population will be treated.

The Hartford sewage treatment plant, which will care for the sewage of the Hartford Metropolitan District, is practically completed and will soon be operating. The plant at Enfield is likewise approaching completion. The town of East Hartford, the only large community in the basin which now discharges raw sewage into the river, has recently completed a preliminary engineering survey leading to construction of a treatment plant.

The principal tributaries to the Connecticut River in Connecticut are the Farmington and Hockanum rivers. The east branch of the Farmington is to be used as an additional source of water supply for Hartford. Analyses of the river at the Tariffville station show some pollution. The Hockanum River analyses at Burnside show very high pollution; the river flows through industrial centers at Ellington, Vernon and Manchester, and is one of the most seriously polluted of all the minor tributaries of the Connecticut River.

There will be a decided improvement in the conditions of the Connecticut River when the treatment plants now under construction in Connecticut are completed and in operation. The next step toward cleaning up the river should be treatment of sewage from large Massachusetts cities.

Water Supply The need as well as difficulty of obtaining suitable water supplies is manifest to a greater degree in the Connecticut and Massachusetts portions of the Connecticut basin, where there are high densities of population, than in the Vermont and New Hampshire sections. Nevertheless, the percentage of cities and towns served by public water supplies is greater in Connecticut and Massachusetts than in Vermont and New Hampshire. The discussion of the water supply problems in the basin will be by states.

Vermont: Towns comprising about 63% of the basin population in Vermont have water service, supplied in most cases by municipally-owned works. The water, derived about equally from ground and surface sources, is in general soft. Tunbridge (pop. 903) is the most notable exception, with its spring water showing a hardness of 180 p.p.m., the highest of any supply in the basin. The potable waters are of good quality, bacterially, according to the annual reports of the Vermont Department of Health. St. Johnsbury, the second largest municipality, uses filtered surface water. At present, the filtering plant is unsatisfactory, and improvements will be necessary in the near future.

Vermont towns of over 1000 population without organized water systems are:

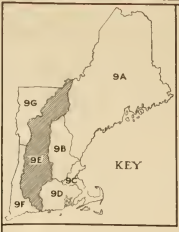
Cavendish	1418	Ryegate	1216
Lunenburg	1400	Weathersfield	1156
Westminster	1324	Concord	1043
Hartland	1266	Burke	1016

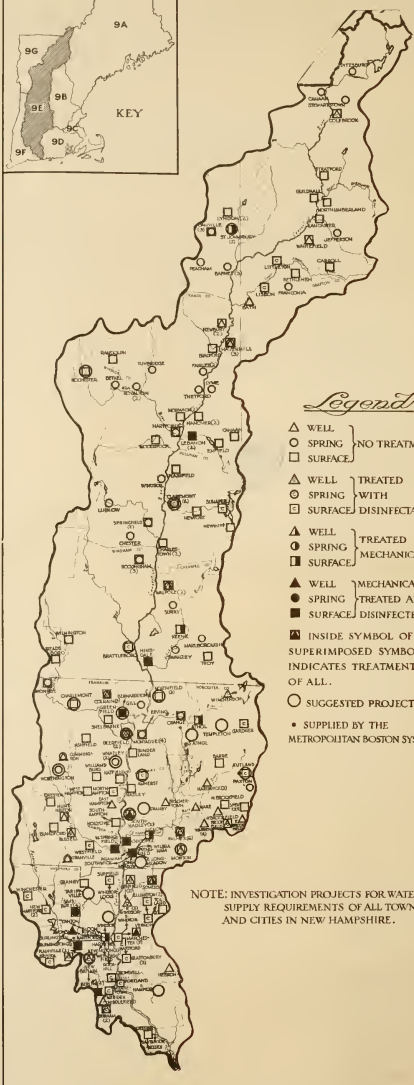
Chelsea 1004

Some 17 other towns with populations between 500 and 1000 are also without supply systems.

New Hampshire: Towns comprising some 80% of the basin population in New Hampshire have water supplies; the majority of the larger supplies are municipally owned and are drawn from surface sources; only a few are ground water supplies. The majority of the small supplies are in semi-public ownership. Several filtration plants are in use, and a few towns employ chlorination. Although there are instances where bacterial records show the need for more extensive chlorination, the 12-year bacterial percentage records show that many systems have maintained a standard higher than that set by the U. S. Public Health Service; in general, the 2-year averages show even less of contamination than the 12-year records, indicating that the quality of water supplies is improving.

MAP Nº 9E





NOTE: INVESTIGATION PROJECTS FOR WATER SUPPLY REQUIREMENTS OF ALL TOWNS AND CITIES IN NEW HAMPSHIRE.

NEW ENGLAND WATER RESOURCES

WATER SUPPLIES

CONNECTICUT BASIN

DEC. 1, 1937

SCALE

0 4 8 16 24 32

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE — DISTRICT NO 1
2100 FEDERAL BUILDING — BOSTON MASSACHUSETTS

Keene, (pop. 13,794) has a public surface supply system which includes slow sand filtration and which has a good bacterial record. Claremont, (pop. 12,377) the next largest town, is served principally by a public surface chlorinated supply. One of Lebanon's supplies, taken from the Mascoma River below Enfield, is filtered and chlorinated before use. One supply with its source in New Hampshire serves towns in both Vermont and New Hampshire.

Fifteen towns with populations from 450 to 1000 are not served by water supplies. The town of Winchester, with a population of 2183, is the only town of over 1000 population without a supply.

Massachusetts: Towns and cities comprising about 96% of the basin population in Massachusetts are served with organized water supply systems. Water works, in general, are publicly owned and are usually small. All the larger works and most of the smaller ones use surface supplies. Chemical analyses show that practically all the ground and surface supplies are soft. The supply of the city of Athol, obtained from Thousand Acre Meadow Brook, shows the highest raw water color. The water is passed through rapid sand filters for the removal of color. Several ground water supplies show high iron content; of these systems nine have iron removal plants. Some of the remaining supplies with high iron content might well be treated for iron removal.

The largest water supply is that of Springfield, which serves also Ludlow, Agawam, Longmeadow, East Longmeadow, Wilbraham and Southwick. It is a public surface supply taken from several sources. All of the water, except that obtained from the Ludlow reservoir, is passed through slow sand filters after coagulation, sedimentation and aeration. The Ludlow supply is filtered at times, and all supplies are chlorinated only during times of emergency. The Holyoke supply, the next largest, is a municipal surface supply drawn from several sources, and is not chlorinated.

A large area of the Connecticut drainage basin in Massachusetts is reserved for the extension of the Metropolitan Water Supply. The flood waters of the Swift and Ware rivers are to be diverted to the water supply system of Boston. While the waters of the Ware River may at times show much color, the long period of storage before use will appreciably improve their quality.

The principal Massachusetts towns without water supplies are:

Templeton	4159	
Buckland	1497	-- supplied in part by Shelburne Falls Fire District.
Hubbardston	1010	

In addition, there are 14 towns with populations ranging from 400 to 1000 which have no water supply systems.

Connecticut: As in Massachusetts, towns and cities comprising about 96% of the basin population in Connecticut are served by organized water systems. Semi-public supplies predominate except in the case of the larger works. Over half of the supplies are taken from surface sources. Modern methods of water treatment, including aeration, coagulation, sedimentation, filtration, chlorination and corrective measures are used extensively.

The bacterial quality of the water is good, partly because only 2.4% of the basin population receives water which is neither chlorinated nor filtered. According to the Connecticut Department of Health, no sewage is discharged into water bodies above any of the public water supply sources.

Several supplies have a hardness above average. Suffield, Somers and East Windsor, all in the same locality, and all having drilled wells of about the same depth, have the hardest water of any supplies in the basin. This fact would indicate that only if no other sources are available should deep wells be used as sources for water supply in this vicinity.

The largest supply is that owned by the city of Hartford which serves Hartford, Bloomfield, Newington, Rocky Hill, Wethersfield, Windsor, West Hartford. The water, taken from the Nepaug and West Hartford reservoirs, is aerated and slow sand-filtered. The present supply will be augmented by the development of additional water sources on the east branch of the Farmington River. Because this river is interstate, a compact between Connecticut and Massachusetts is a necessary prerequisite to protection of the Massachusetts portion of the watershed.

A measure empowering the Massachusetts Department of Public Health to protect the Farmington watershed because it is tributary to the proposed new source of the Hartford water supply was presented by that Department to the 1937 Legislature. Instead of recommending passage of this bill the Committees on Public Health and Water Supply, sitting jointly, reported a Resolve, subsequently passed, which provided "for an investigation by a special unpaid commission relative to protecting the purity of (all) interstate waters used for drinking purposes". (Chap. 51, Acts of 1937, Mass. Legislature)

New Britain has the second largest supply in the Connecticut part of the basin. Its main supply, from surface sources, is chlorinated before use. The water from its auxiliary well supply is of such good quality that chlorination is not necessary. Table V-E lists pertinent data for those communities now served by water systems. The larger communities without supplies are:

Easthampton	2616	East Haddam	2114
South Windsor	2535	Haddam	1755
Colchester	2134	Middlefield	1204
	Burlington 1082		

All towns with populations under a thousand, with the exception of Hebron (pop. 879), are without water supply systems.

Flood Control From the beginning of settlement in the Connecticut River valley the occurrences of floods have been recorded. As the population increased, as industry grew, and as power development became important, the effect of floods on the river became more and more marked. Mills were located on the river banks to make use of the head available for power purposes. In some cases encroachments on the river have tended to raise the natural flood stage. Highways and railroads have been carried over the river at points convenient to serve industries, cities and towns, but in many cases at elevations too low to clear the water levels attained by high floods.

Normally, as the snow cover melts and heavy spring rains come, there is in the river an increased flow which frequently reaches flood proportions. By months, the percentage of frequency of the larger floods appears to be: April, 34%; March, 27%; February, 10-11%; May, 7%; and November 3½%. The remaining 5% of floods have occurred in July, August, October and December. This distribution is based on a list of the important floods from 1639 to 1937.

It is notable, however, that the second highest peak discharge recorded occurred in November, a month in which major flood occurrences are infrequent. It is also of interest that the highest and second highest flood peaks have occurred within the last ten years. The flood of November, 1927, was estimated to be in the order of a 100-year flood and that of March, 1936, a 300- to 500- year flood. Although so-called 100-year and 300-year floods have been experienced in the last ten years, it is entirely possible that floods of equal or greater intensity may occur on the Connecticut in the next few years.

The 1936 flood, exceeding and following so closely that of 1927, has spurred local groups and State and Federal governments to devise means of prevention of losses from future large floods. After the Federal Government, in 1936, passed a Flood Control Act, the New England States affected entered into joint compacts to smooth out inherent difficulties arising from interstate drainage and to provide for the acquisition of lands for and the continued management, maintenance and operation of flood control works that may be constructed.

Initial Flood Control Work Authorization Under the Flood Control Act of 1936, Public Document No. 738, 74th Congress, (approved June 22, 1936), certain "works of improvement for the benefit of navigation and the control of destructive floods and other purposes" were authorized by the Federal Government, these works, according to the terms of the Act, to be designated by the President in the order of their emergency and to be carried out under the direction of the Secretary of War and the supervision of the Chief of Engineers. Under this Act, provision was made: "That penstocks or other similar facilities, adapted to possible future use in the development of adequate electric power, may be installed in any dam herein authorized when approved by the Secretary of War upon the recommendation of the Chief of Engineers."

For the Connecticut River basin the Act provides for "construction of ten reservoirs in Vermont and New Hampshire on tributaries of the Connecticut River; plans in House Document No. 412, 74th Congress, 2nd session, as the same may be revised upon further investigation of the 1936 flood; estimated construction cost $10,028,900; estimated cost of land and damages $3,344,100".

An amendment to the bill authorizes also construction of reservoirs on tributaries of the Connecticut River in Massachusetts, in accordance with stipulations in the Interstate Compacts.

Interstate Compacts for Flood Control — On June 3, 1936 (prior to passage of the Flood Control Act) the four states in the Connecticut Valley organized a joint Interstate compact commission on flood control. This Commission, the Governors, and other representatives of the four New England States jointly interested in Connecticut Valley flood control met at Hartford, March 8, 1937, with the Secretary of War and the Chief of Engineers, for the purpose of working out definite means of interstate cooperation in matters of flood control. The Governors appointed a committee of twelve -- three from each of the states -- to reach agreements and to formulate the terms of an interstate compact.

This Interstate Compact Committee prepared agreements which were presented to and approved by the State Legislatures in the 1937 sessions, and were subsequently submitted to the U. S. Congress for final ratification. Opposition to final approval of the compact developed early. The Federal Power Commission objected upon the ground that the compact, by reserving to the States such rights as they already had in connection with the development of power, was in violation of the national policy established by the Federal Power Act. A second Administration objection developed a little later, based on the ground that the compact did not provide that the lands to be furnished by the States at their expense were to be deeded to the Federal Government. The Commerce Committee of the Senate which heard the proposed bill approved it without reservation of any kind. The House Committee, after hearing the bill, apparently arrived at the same conclusion as the Senate Committee, that is, that the compact complied with the requirements of the Omnibus Flood Control Bill, and likewise approved it, with a simple reservation which stipulated that the compact should not be considered as diminishing or impairing the authority now possessed by the War Department and the Federal Power Commission over public waters.

The Interstate Compact Committee received from the U. S. Army Engineers detailed information on a comprehensive program for flood control in the Connecticut River basin. This plan included twenty reservoirs, of which thirteen would be in Vermont, three in New Hampshire, and four in Massachusetts. It was estimated that these reservoirs would control about 2279 square miles, about 20% of the basin drainage area. To supplement the reservoirs a system of dikes along the river banks at Hartford, East Hartford, in Connecticut, and at Springfield, West Springfield, Chicopee, Holyoke and Northampton, in Massachusetts, was included in the program.

The cost estimate of this tentative comprehensive plan as given in a report of the Massachusetts State Planning Board is summarized below:

Item of Work	Estimated Cost to Federal Government (Construction chiefly)	Estimated Cost to Local interests (Land, Damages, etc.)	Total Estimated Cost	Annual maintenance and operation
Reservoirs	$24,261,000.	$10,575,000.	$34,836,000.	$200,000.
Dikes	8,562,000.	3,603,000.	12,165,000.	87,000.
TOTALS	$32,823,000.	$14,178,000.	$47,001,000.	$287,000.

A pressing problem before the Committee was to formulate a program for immediate execution, the cost of which would come within the present financial ability of the several states, and would keep, as well, within the funds allotted by the Federal Government for initial flood control construction in the Connecticut River basin.

With such a plan in mind the Connecticut River Interstate Compact was drawn up specifying a group of eleven reservoirs. These reservoirs, indicated on the basin map No. 10-E and on the river profile No.7, are:

Site	River	Drainage Area (Sq.Mi.)	Below Spillway Capacity (Acre-Feet)	Storage Equivalent (inches of run-off)
Victory, Vt.	Passumpsic	66.	24,600	7.
Union Village, Vt.	Ompompanoosuc	126.	30,200	4.5
North Hartland, Vt.	Ottauquechee	222.	48,500	4.1
Groton Pond, Vt.	Wells	17.3	6,500	7.
Bethlehem Jct., N.H.	Ammonoosuc	90.	24,200	6.
Stocker Pond, N.H.	Sugar	34.4	11,300	6.
Surry Mountain, N.H.	Ashuelot	100.	32,000	6.
Knightville, Mass.	Westfield	164.	15,800	4.5
Tully, Mass.	Millers	50.	55,700	8.
Priest Pond, Mass.	Millers	18.8	23,200	6.
Lower Naukeag, Mass.	Millers	19.7	5,600	5.1

Of the eleven reservoirs listed, eight would be selected for immediate construction, as follows: three of the four in Vermont; the three in New Hampshire; and two of the four in Massachusetts.

The Connecticut Valley Compact contains thirteen articles defining the purpose, scope, terms and method of administration. For the eight reservoirs specified, the cost is estimated at $12,728,900., of which the Federal Government's share would be $10,028,900. chiefly for the construction, and the states' share would be about $2,700,000. for land, easements, relocations, damages, and other costs.

Of the estimated cost to the states, the following division of payment was agreed upon by the Compact Committee, and subsequently by the Legislatures:

Massachusetts	50%
Connecticut	40%
New Hampshire	5%
Vermont	5%

The Compact provides, under Article II, that there be "created 'The Connecticut River Valley Flood Control Commission,' hereinafter referred to as the Commission, which shall consist of twelve commissioners" -- three from each of the signatory states. As a body corporate and politic this Commission has authority and power to carry out the terms and responsibilities stipulated in and delegated to it by the Compact.

One of its important duties is to collect from the States and disburse funds necessary for acquisition of the reservoir sites and for maintenance and operation of the reservoirs. Payment of the states' shares as given above would be

made as requested after July 1, 1937, but not more than one-half of the total amount could be required in any one year. Each of the signatory states would contribute, after its initial investment, a corresponding proportion of the maintenance and operating expenses. These payments likewise would be made to the Commission.

Existing Storage There are numerous power developments within the basin, with varying amounts of pondage, but with no great storage capacity. The few reservoirs which have real storage value are located on the upper Connecticut, Mascoma, Sugar, Deerfield, Westfield, and Farmington rivers. Their total storage capacity is about 467,000 acre-feet. With some allowance for miscellaneous storage in the other known ponds, it may be stated conservatively that the total existing usable storage capacity is in excess of 500,000 acre-feet.

This total includes the Lower Fifteen-Mile Falls Reservoir, with an effective capacity of 33,000 acre-feet, which will probably be utilized for stream regulation until the Upper Fifteen-Mile Falls development is constructed. At that time, effective storage of 114,000 acre-feet will be obtainable in the upper pond, and the lower pond will be used for purposes of head and pondage only. Thus the net increase in effective storage capacity will be 81,000 acre-feet.

In addition to the 500,000 acre-feet noted above, the proposed storage development on the upper Connecticut River at Pittsburg, New Hampshire, will provide about 96,000 acre-feet.

Another reservoir of some possible value as a means of flood control is the Quabbin Water Supply Reservoir on the Swift River, now under construction by the Metropolitan District Commission of Massachusetts. When completed, this will be by far the largest reservoir in the basin, and will store 1,274,000 acre-feet of water, although it will control only 187 square miles of watershed.

Excluding the Quabbin development, the largest amount of storage on any of the tributaries is that on the Deerfield River at the Harriman and Somerset Reservoirs. These two provide 178,000 acre-feet of storage, which corresponds to 18 inches of run-off on the drainage area of 184 square miles. As this depth in run-off is a large part of the average annual run-off, the reservoirs provide excellent control of flood flows in addition to increased low flow for power. This relationship of storage to depth of run-off is exceeded only by that of the Cobble Mountain Reservoir on the Westfield River, and by that of the Upper Connecticut Lakes.

The following table summarizes the major storage reservoirs existing or under construction:

			STORAGE CAPACITY		
Reservoir	River	Drainage Area (Sq. Mi.)	Acre-feet	Depth in inches of runoff	Acre-feet per (Sq.Mi.)
Upper Conn. Lakes	Connecticut	82	88,300	20.	1080
Lower Fifteen-Mile Falls	Connecticut	(1659)	33,000	(0.4)	(20)
Grafton Pond, Goose Pond, Crystal & Mascoma Lakes	Mascoma	153	28,800	3.5	188
Sunapee Lake	Sugar	45	19,800	8.2	440
Harriman & Somerset	Deerfield	184	178,000	18.	970

(cont.)

Reservoir	River	Drainage Area (Sq.Mi.)	STORAGE CAPACITY Acre-feet	Depth in inches of Runoff	Acre-feet per (Sq.Mi.)
Cobble Mountain	Westfield	45	62,000	25.5	1380
Otis, Compensation & Nepaug	Farmington	112	56,600	9.4	500
	Total (2280)	621	466,500	14.	750
	Misc.		33,500		
	Total Existing		500,000		

Note: parentheses inclose figures which are insignificant from point of view of flood control.

Construction Under Way or Pending

Pittsburg	Connecticut	84	98,500	21.4	1150
Quabbin (Met.Dist.Com.)	Swift	187*	1,274,000	127.	6800

* By the possible diversion of flood flows from the Ware River the area controlled, so far as floods are concerned, might be increased to a total of 287 square miles.

The ultimate capacity of the Quabbin Reservoir is several times greater than the amount of annual precipitation on the Swift and Ware River watersheds alone. In order to disturb as little as possible the normal flows utilized by existing interests on the river downstream from this reservoir, only flood flows will be diverted from these and, if necessary, other nearby drainage areas. If the Swift and Ware River watersheds are not capable of meeting the demands of the Metropolitan Supply there may ultimately be diverted into the Quabbin Reservoir flood flows, at least in part, from more than 1000 square miles of additional drainage area (comprising an area equal to about one-eighth the area of the state of Massachusetts) in the Millers, Deerfield, Quaboag, and Westfield River watersheds. For the present, however, the flood control value of the Quabbin Reservoir will affect only the Swift River area of 187 square miles directly and the Ware River diversion area of 100 square miles to a lesser extent.

Excluding the large Fifteen-Mile Falls area, but including the Pittsburg and Swift and Ware River areas, there will soon be 1000 square miles, about 9% of the total Connecticut River basin area, tributary to storage of sufficient magnitude to control floods and regulate low flows. When and if flood flows are diverted to the Quabbin Reservoir from the other areas mentioned above, the total controlled area will be doubled.

Proposed Flood Control Storage Storage possibilities in the Connecticut River basin have been studied and reported on by individual consulting engineers and state agencies and by the Federal Government through the Army Engineers. Recent extensive investigations have been carried on by the Army Engineers to determine which would be economically feasible for development.

As reported in Document #412, 74th Congress, 2nd Session ("308" Report) from a group of about 300 projects in the Connecticut basin studied for storage and power possibilities, 33 were selected to form an ultimate plan of flood control.

Of these 33 projects, 10 were chosen as best suited to incorporation in an initial flood control plan: Lyndonville, Lyndon Center and Victory, on the Passumpsic River; Bethlehem Junction and Gale River, on the Ammonoosuc River; Union Village, on the Ompompanoosuc River; Gaysville, Ayers Brook and South Tunbridge, on the White River; and Bridgewater Corners, on the Ottauquechee River.

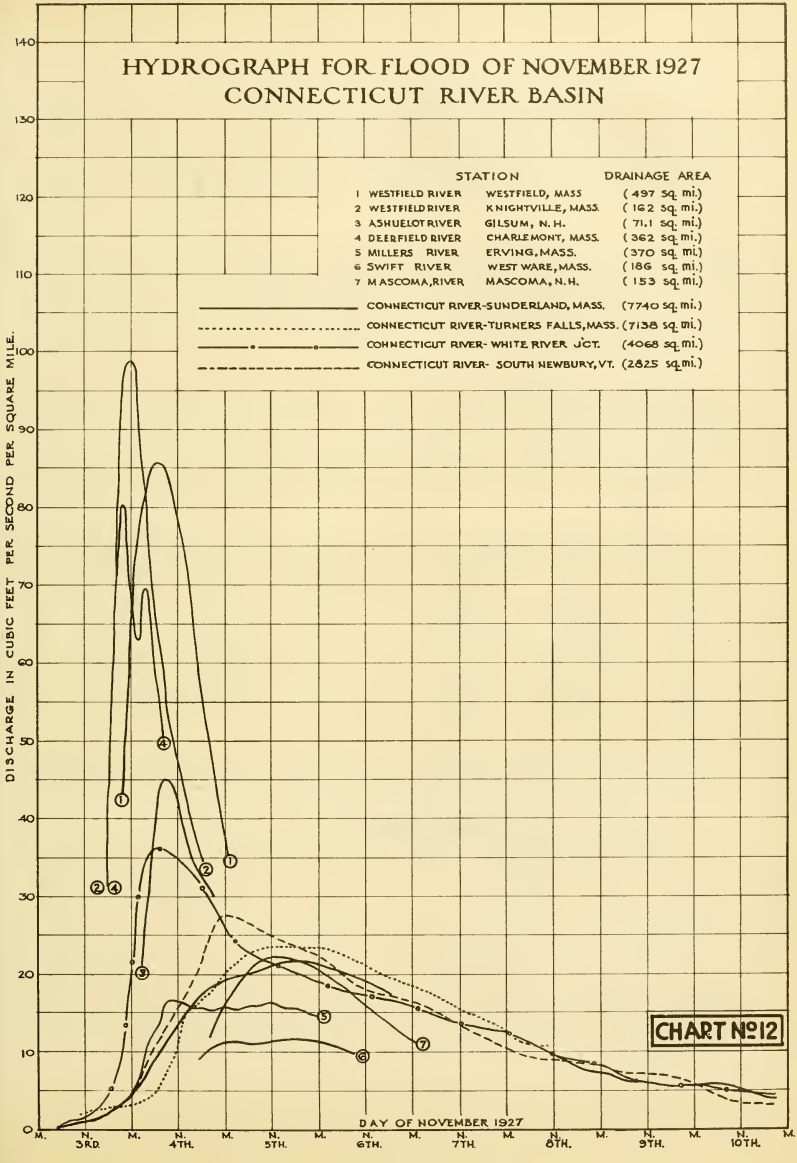
The Flood Control Act of 1936 authorized an expenditure of $13,411,400 for a reservoir system in the Connecticut Valley. It also authorized the revision of the "Initial" plan of H. D. 412 in the light of the effects of the 1936 flood.

Studies made as a result of this authorization resulted in substitution of other reservoirs for those listed in H. D. 412. The 1936 flood was of a greater magnitude in the lower valley and indicated the desirability of locating many reservoirs lower down in the watershed. Eight reservoirs were selected for the definite project of this authorization.

These eight reservoirs coincided with those included in the Interstate Compact for the Connecticut Valley agreed upon by the four states in 1937.

The total cost of this group of reservoirs is $10,028,900 Federal cost, $2,700,000 State cost. The annual charges are $727,600. The acre-feet of storage of the reservoirs in this project is 242,300. The total annual direct and indirect benefits of these reservoirs exceed the annual charges. As a result of an extensive investigation the total losses, direct and indirect, due to the 1936 flood were estimated to be $67,000,000.

An additional report based upon studies of the cost and benefits resulting from a larger system of reservoirs and other flood control works to give flood control protection to the valley as justified by damage from all past floods, has been made by the Army Engineers. This plan included the use of levees or dikes in the large congested centers on the Connecticut River. The study included an analysis of the economic justification for such a system.


HYDROGRAPH FOR FLOOD OF NOVEMBER 1927
CONNECTICUT RIVER BASIN
STATION
DRAINAGE AREA
1 WESTFIELD RIVER WESTFIELD, MASS (497 sq. mi.)
2 WESTFIELD RIVER KNIGHTVILLE, MASS. (162 sq. mi.)
3 ASHUELOT RIVER GILSUM, N. H. (71.1 sq. mi.)
4 DEERFIELD RIVER CHARLEMONT, MASS. (362 sq. mi.)
5 MILLERS RIVER ERVING, MASS. (370 sq. mi.)
6 SWIFT RIVER WEST WARE, MASS. (186 sq. mi.)
7 MASCOMA, RIVER MASCOMA, N.H. (153 sq. mi.)
CONNECTICUT RIVER-SUNDERLAND, MASS. (7740 sq. mi.)
CONNECTICUT RIVER-TURNERS FALLS, MASS. (7138 sq. mi.)
CONNECTICUT RIVER- WHITE RIVER JCT. (4068 sq. mi.)
CONNECTICUT RIVER- SOUTH NEWBURY, VT. (2825 sq. mi.)
DISCHARGE IN CUBIC FEET PER SECOND PER SQUARE MILE.
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
M.
N.
3RD.
4TH.
5TH.
6TH.
7TH.
8TH.
9TH.
10TH.
DAY OF NOVEMBER 1927
CHART Nº12

Flood Flows Flood records on the Connecticut River date back about 300 years, although the early records are scant and the information meagre. At the time of the 1927 flood, much information was gathered in regard to flood crests, discharges, and damages occasioned; since then records have been much more comprehensive, and gaging stations have been added or improved on many important tributaries. Details of these records are given in Federal and State publications.

Almost complete records are at hand covering the 1927 and 1936 floods. The 1927 flood is classed as an "up-river" flood, since the more serious losses were experienced in the upper reaches of the river, mainly in Vermont. The 1936 flood is classed as a "down-river" flood, as the greatest amount of damage was incurred along the lower reaches of the river, in Massachusetts and Connecticut.

The following table shows, for the days of greatest flow during the two floods, the runoff characteristics in the lower reaches of the river. The basic records are for Sunderland (8390 square miles) in the 1927 flood, and for Montague City (8340 square miles) in the 1936 flood. For practical purposes these stations are considered as coincident; the depth of runoff in inches is felt to be applicable to the drainage areas above such points as Northampton, Holyoke, Springfield and Hartford.

	November, 1927 Flood			March, 1936 Flood		
No. of Days	Discharge Sec-ft. Days	Volume in Acre-ft.	Depth of Runoff in Inches	Discharge Sec-ft Days	Volume in Acre-ft.	Depth of Runoff in Inches
1	160,000	317,000	0.75	233,000	460,000	1.1
2	304,000	602,000	1.4	449,000	890,000	2.1
3	408,000	810,000	1.9	636,000	1,260,000	3.0
4	519,000	1,030,000	2.4	805,000	1,600,000	3.8
5	590,400	1,170,000	2.7	963,000	1,910,000	4.6
6	641,000	1,270,000	3.0	1,107,000	2,200,000	5.2
7				1,229,000	2,430,000	5.8

The extended effect of the 1936 flood in the lower reaches of the river is shown by the following average flood duration trends:

	Runoff Intensity in Second Ft. per Sq. Mi.							
Flood Trend	12	16	20	22	24	26	28	30
1936 Flood duration in days	$7\frac{3}{4}$	$5\frac{3}{4}$	$4\frac{1}{2}$	$3\frac{3}{4}$	3	$2\frac{1}{4}$	$1\frac{3}{4}$	Ave.peak
1927 Flood duration in days	$3\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{1}{4}$	Ave.peak				

Flood Damages and Benefits Summarized According to estimates prepared by the U. S. Army Engineers, the direct losses caused by the 1927 and 1936 floods in the Connecticut River valley were:

State	1927	1936
Vermont	$10,981,000	$1,765,000
New Hampshire	1,767,000	2,268,000
Massachusetts	2,157,000	19,144,000
Connecticut	621,000	11,745,000
Total	$15,526,000	$34,922,000

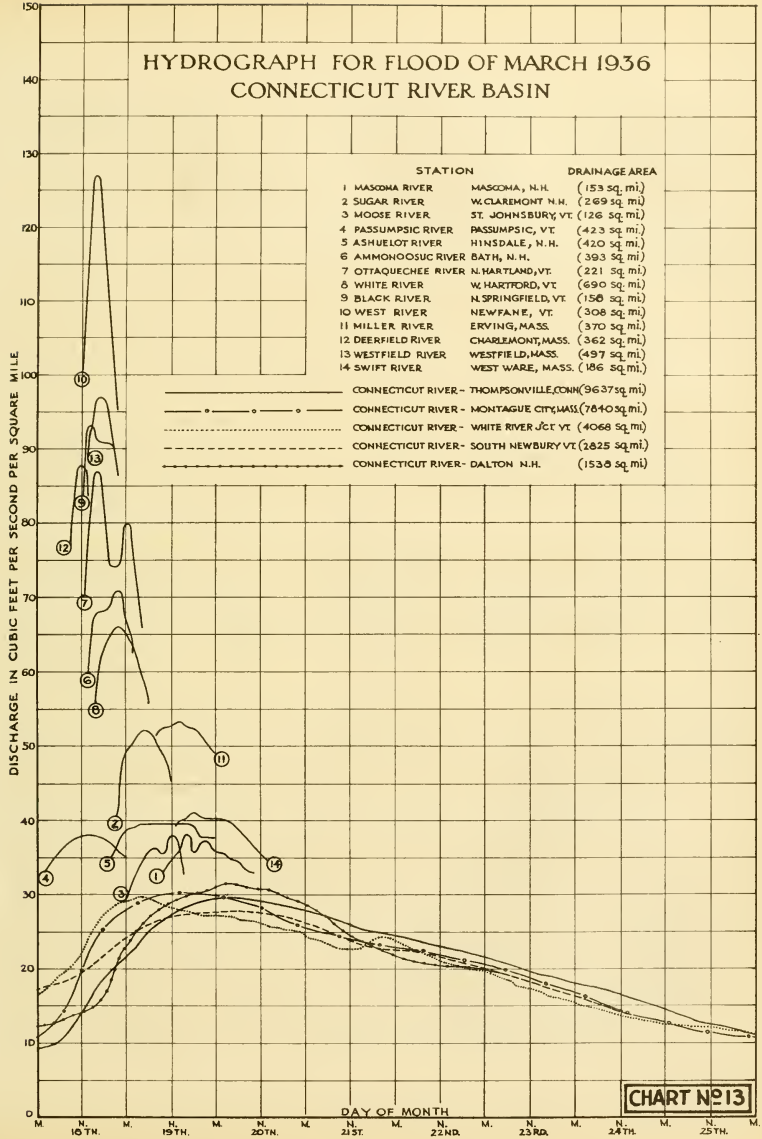
Of the total direct damages in the basin for the 1936 flood of $34,922,000, about 15% occurred on the tributaries; about one-third of the losses on the tributaries occurred in the Millers River basin. These amounts take no account of indirect losses. From an analysis by the Army Engineers of 342 questionnaires which covered about 14% of the entire direct losses returned from the States of Massachusetts, New Hampshire and Connecticut, it would appear that the indirect losses which could be expressed in terms of the dollar amounted to about 74% of the direct losses.

If there is added to this figure an estimate for "intangible" losses, the total of indirect losses resulting from the 1936 flood very nearly equals the total of direct losses in the Connecticut basin.

It has been estimated that property valued at nearly $300,000,000 was subject to inundation during the 1936 flood. With reasonable flood control works considerable appreciation in the value of this property may well be expected.

Annual Charges The estimated annual charges for the fifteen reservoirs selected by the Army Engineers are based generally on interest rates of 4% on the Federal and 5% on local costs. The developments would be amortized over a period of 50 years. Annual maintenance and operation has been estimated as follows: for earth dams, from $500 to $3500 depending on the yardage involved; for concrete work, 1% of the cost; for machinery, including gates, 3%; for operation, $5,000, including $1500 for operator when the dam is gate-operated, $500 for expenses, and $3000 for general overhead; and in addition, whatever amount appears to represent the excess cost of maintenance of new roads over that of roads now existing.

Article XI of the Interstate Compact stipulates also that "As a part of the expense of operation and maintenance of said reservoirs the Commission shall assume and pay to the respective towns entitled thereto the cost of reimbursement for loss of taxes as set forth and required in sub-paragraph (c) in Article VI hereof, and shall pay all costs incident to or damages resulting from the operation and maintenance of such flood control reservoirs . . . . . and shall pay all other costs or expenses . . . . . including the expenses of the members of said Commission."


HYDROGRAPH FOR FLOOD OF MARCH 1936
CONNECTICUT RIVER BASIN
STATION
DRAINAGE AREA
1 MASCOMA RIVER MASCOMA, N.H. (153 SQ. MI.)
2 SUGAR RIVER W. CLAREMONT N.H. (269 SQ. MI)
3 MOOSE RIVER ST. JOHNSBURY, VT. (126 SQ. MI.)
4 PASSUMPSIC RIVER PASSUMPSIC, VT. (423 SQ. MI.)
5 ASHUELOT RIVER HINSDALE, N.H. (420 SQ. MI.)
6 AMMONOOSUC RIVER BATH, N.H. (393 SQ. MI)
7 OTTAQUECHEE RIVER N. HARTLAND, VT. (221 SQ. MI.)
8 WHITE RIVER W. HARTFORD, VT. (690 SQ. MI.)
9 BLACK RIVER N. SPRINGFIELD, VT. (158 SQ. MI.)
10 WEST RIVER NEWFANE, VT. (308 SQ. MI.)
11 MILLER RIVER ERVING, MASS. (370 SQ. MI.)
12 DEERFIELD RIVER CHARLEMONT, MASS. (362 SQ. MI.)
13 WESTFIELD RIVER WESTFIELD, MASS. (497 SQ. MI.)
14 SWIFT RIVER WEST WARE, MASS. (186 SQ. MI.)
CONNECTICUT RIVER - THOMPSONVILLE, CONN (9637 SQ. MI.)
CONNECTICUT RIVER - MONTAGUE CITY, MASS. (7840 SQ. MI.)
CONNECTICUT RIVER - WHITE RIVER JCT. VT. (4068 SQ. MI)
CONNECTICUT RIVER - SOUTH NEWBURY VT. (2825 SQ. MI.)
CONNECTICUT RIVER - DALTON N.H. (1538 SQ. MI)
DISCHARGE IN CUBIC FEET PER SECOND PER SQUARE MILE
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
M.
N.
18TH.
19TH.
20TH.
21ST.
22ND.
23RD.
24TH.
25TH.
DAY OF MONTH
CHART No 13

General Conclusions A carefully planned improvement and development of the headwaters area is a very important part of an integrated watershed program. The management of the headwaters land to promote the growth of vegetation best adapted to retard the runoff, encourage the conservation of ground water, and prevent erosion is important to supplement all other improvements for the reduction of floods, the abatement of pollution, and the conservation of water. The importance of this program is somewhat reduced by the fact that, for about 60 years, there has been a steady abandonment of farms in the upland area, accompanied by a natural reforestation or reseeding of tillage and pasture land until nearly 80% of the basin area in New Hampshire and Vermont is now covered with some sort of forest growth.

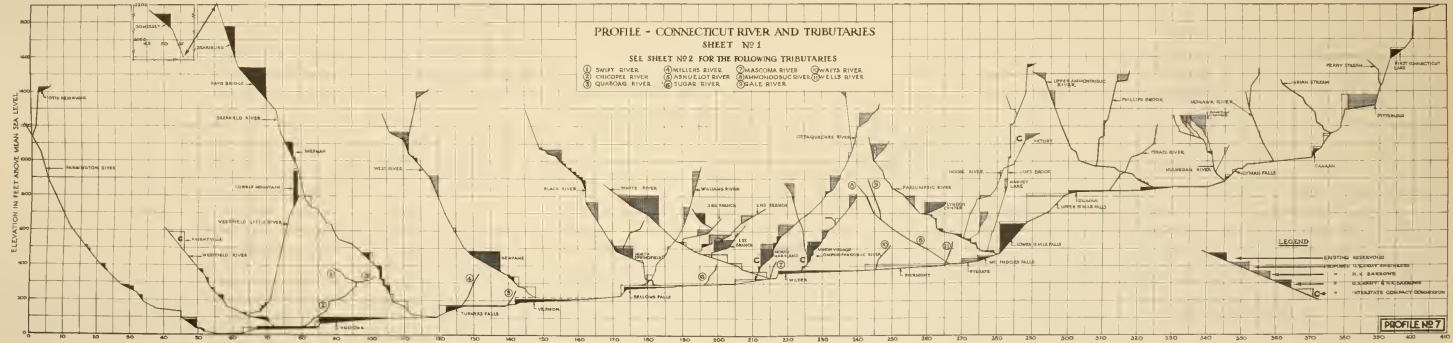
There are many small headwaters storage sites which should be further investigated, and where possible they should be improved to supplement the storage in the larger reservoirs in the downstream areas.

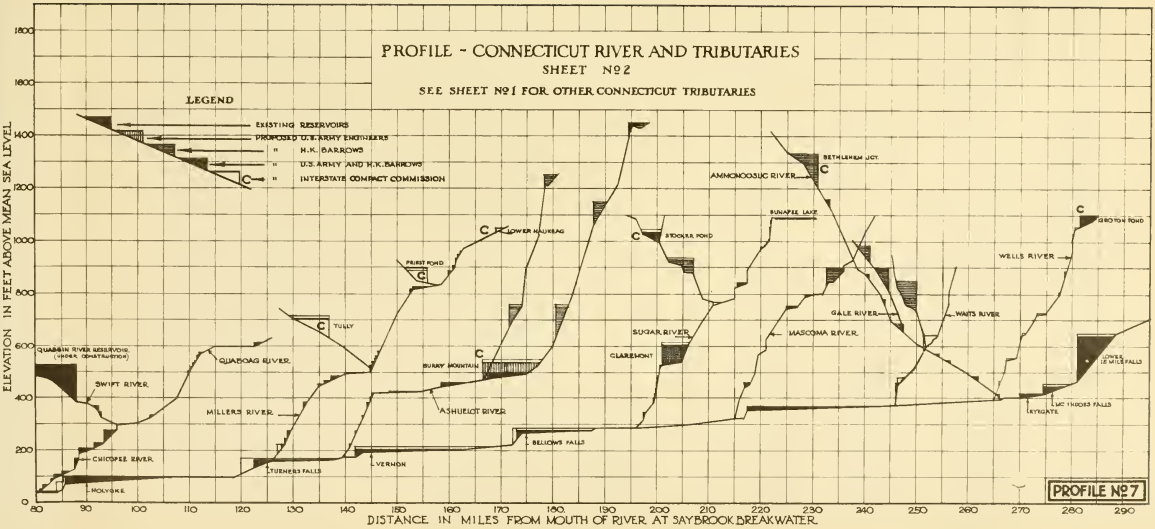
The size of the Quabbin Reservoir is such that a great amount of benefit should accrue for flood control. It would appear desirable that the program of development involving the flood flow diversions contemplated for Quabbin should be studied and worked out cooperatively with the Connecticut River flood control program so as to obtain the most effective use of the investments made.

It seems advisable that some impartial agency be made responsible for coordinating operation of all storage reservoirs, existing and future, within the Connecticut River basin, in order that the regulation of flows in this river may be of the utmost advantage to all concerned. The degree to which regulation can be coordinated will in part determine the degree to which future investments for water use and control projects on the Connecticut can be justified.

It is generally conceded that to control floods in the Connecticut Valley reservoirs must be constructed on the tributary streams. It is not known what proportion of the cost should be charged to flood control. The Army Engineers state that, in the case of the Compact reservoirs, "the total annual direct and indirect benefits ... exceed the annual charges." H. K. Barrows states that "flood relief alone will not justify an expenditure of more than about $20,000,000;" and that "the cost of a reservoir and dike system to prevent damaging floods will be roundly $50,000,000." It is the contention of the Vermont Flood Compact Board that a comprehensive power-storage reservoir system, such as that advocated by Professor Barrows in his 1928 and 1930 reports, would "result in other losses to the State (Vermont) compared to which the dollars and cents cost of construction and land purchases would be small indeed. Due to a combination of the topography and the organization of the governmental units in the State, the construction of all the proposed reservoirs would result in the elimination of a number of our towns; would restrict further development of Recreation in a large section of the State; would measurably reduce the profitable agriculture of the State."

Obviously, a complete solution of the flood control problem is impossible until there can be reconciliation of these conflicting views. However, inasmuch as all four States in the Connecticut Valley and the Army Engineers are agreed that the program called for in the Interstate Compact is a valid and effective step in any long-term flood control program which may be worked out, it is desirable that the provisions of this Compact be carried out in order that a real start may be made toward relieving one of New England's most acute water resources difficulties.


PROFILE - CONNECTICUT RIVER AND TRIBUTARIES
SHEET Nº 1
SEE SHEET Nº 2 FOR THE FOLLOWING TRIBUTARIES
1 SWIFT RIVER
2 CHICOPEE RIVER
3 QUABOAG RIVER
4 MILLERS RIVER
5 ASHUELOT RIVER
6 SUGAR RIVER
7 MASCOMA RIVER
8 AMMONOOSUC RIVER
9 ALE RIVER
10 WAITS RIVER
11 WELLS RIVER
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DISTANCE IN MILES FROM MOUTH OF RIVER AT SAYBROOK BREAKWATER
LEGEND
PROFILE Nº 7


PROFILE - CONNECTICUT RIVER AND TRIBUTARIES
SHEET №2
SEE SHEET №1 FOR OTHER CONNECTICUT TRIBUTARIES
LEGEND
EXISTING RESERVOIRS
PROPOSED U.S. ARMY ENGINEERS
" H.K. BARROWS
" U.S. ARMY AND H.K. BARROWS
" INTERSTATE COMPACT COMMISSION
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DISTANCE IN MILES FROM MOUTH OF RIVER AT SAYBROOK BREAKWATER
QUABBIN RIVER RESERVOIR (UNDER CONSTRUCTION)
SWIFT RIVER
QUABOAG RIVER
MILLERS RIVER
CHICOPEE RIVER
HOLYOKE
TURNERS FALLS
VERMONT
TULLY
PRIEST POND
BURRY MOUNTAIN
ASHUELOT RIVER
BELLOWS FALLS
LOWER NAUKEAG
STOCKER POND
SUGAR RIVER
CLAREMONT
AMMONOOSUC RIVER
BETHLEHEM JCT
PUNAPEL LAKE
MASCOMA RIVER
GALE RIVER
WAITS RIVER
WELLS RIVER
BROTON POND
LOWER 12 MILE FALLS
LUCTHOOKS FALLS
EXTGATE
PROFILE №7

H. K. Barrows, Chairman of the Water Resources Committee of the New England Regional Planning Commission, has presented on his own responsibility the following memorandum, which we attach hereto:

"The recent serious floods on Connecticut River have included that of 1927, with a total direct damage of about $15,000,000 and that of 1936, with a total direct damage of about $31,000,000. These two floods showed peak flows on the lower river (near Sunderland and Holyoke) of about 170,000 and 230,000 c.f.s. respectively and frequencies of about 100 years and 500 years respectively. At a flow of about 120,000 c.f.s. damages are nominal.

"The frequency study of all damaging floods shows a yearly flood damage of about $400,000 based on direct damages alone. Indirect damages will add approximately the same amount, so that all flood damages result in a yearly loss of about $800,000 or say $1,000,000.

"The cost of a reservoir and dike system to prevent damaging floods will be roundly $50,000,000. requiring yearly charges of 5 to 6% or $2,500,000 to $3,000,000 yearly. It is obvious therefore that flood relief alone will not justify an expenditure of more than about $20,000,000.

"The U. S. Engineer Corps estimates yearly flood damages (or benefits) for all floods as follows:-

(1)	Direct	$ 854,400
(2)	Indirect	816,400
(3)	Restoration of property values or depreciation	3,597,200
	Total,	$5,268,000 yearly.

"The sum of items (1) and (2) alone or about $1,670,000 yearly, includes all damages for all floods. The third item represents a less dependable method of arriving at the same result; viz- the sum of items (1) and (2). Either method gives a determination of yearly flood benefits but the first, based on tangible figures of damage, is a much more certain method than that based on estimating depreciation. The latter, "based upon a few sales subsequent to the 1936 flood," is mere speculation and does not give the ultimate true depreciation.

"In any event, to include data of both damages and depreciation is adding together two determinations of the same quantity.

"The yearly item of $3,597,200 should therefore be stricken out as all flood benefits are definitely included in the first two items. This leaves about $1,670,000 yearly of flood benefits where $2,500,000 to $3,000,000 will be required for yearly charges on the reservoirs and dikes ....

"On both the Connecticut and Merrimack River basins the general solution of the problem of flood relief is an extensive system of storage reservoirs, designed and operated for economic power production, but providing flood protection as a large accompanying benefit."

Power The Connecticut River and its tributaries constitute the most important source of water power in New England. Present wheel installations total nearly 800,000 horse power.

There is a fall of about 1600 feet in the main river between First Connecticut Lake and tidewater, at Hartford, Connecticut, and nearly 600 feet of this fall is at present developed. The largest dams are at the following locations:

Plant	Net Head (ft.)	Wheel Capacity HP
Fifteen Mile Falls (Comerford)	175	215,000
McIndoes Falls	27	16,500
Wilder	35	5,000
Bellows Falls	62	66,000
Vernon	34	41,700
Turners Falls	59	78,200(a)
Holyoke	50	66,070(b)
Total	442	488,470

(a) 3 plants
(b) 5 plants

The other six developed sites on the main river have a total capacity of 12,974 horse power. Of the 501,444 horse power, 354,850 horse power, developed under a total head of 447 feet, is on that part of the Connecticut River above the Massachusetts line. In Massachusetts, 109 feet of head are utilized to develop 144,270 horse power; in Connecticut, 2324 horse power are developed under a head of 34 feet.

Developments on the tributary streams total 312,935 horse power, divided among the four states as follows:

State	Total Installation - HP
New Hampshire	21,530
Vermont	87,955
Massachusetts	172,987
Connecticut	30,463

The Deerfield River, in Vermont and Massachusetts, is the most highly developed tributary, with 8 plants utilizing nearly 1200 feet of head to develop about 130,000 horse power.

The power developments are benefited by numerous storage reservoirs throughout the basin. The total usable storage capacity, as given by the U. S. Army Engineers (House Document #412, 74th Congress, 2nd Session), is about 490,000 acre-feet. The storage reservoirs of greatest capacity are:

Storage Reservoir	River	Effective Capacity (Acre-feet)
Connecticut Lakes	Connecticut	88,300
Lower Fifteen Mile Falls	"	33,000
Goose Pond	Mascoma	11,000

Storage Reservoir(cont'd)	River	Effective Capacity (Acre-feet)
Mascoma Lake	Mascoma	11,400
Sunapee Lake	Sugar	19,800
Somerset Reservoir	Deerfield	62,000
Harriman Reservoir	"	116,000
Cobble Mountain Reservoir	Westfield	62,000
Otis Reservoir	Farmington	18,400
Compensation Reservoir	"	9,200
Total		431,100

Although the most economical water power sites are already developed, many undeveloped sites are available, particularly on the Vermont and New Hampshire tributaries. However, the feasibility of the development of these potential sites will depend on the extent to which new storage can be developed. Redevelopment of existing plants can likewise be justified only if additional storage is provided.

Studies of power and storage have been made by state agencies and by the U. S. Army Engineers. A report, prepared for the Advisory Committee of Engineers on Flood Control for the State of Vermont (1928-1930), listed over 40 power and storage sites on the Vermont tributaries as suitable for future development.

A report prepared for the State of New Hampshire in 1934 described several sites on the New Hampshire tributaries to the Connecticut as feasible for development.

In the U. S. Army Engineers' 1936 "308" Report on the Connecticut a comprehensive plan for the ultimate development of power in the basin was submitted. This plan included 19 storage reservoirs, with an effective storage capacity of 770,300 acre-feet, to be utilized for the benefit of downstream power plants; and 22 power developments with installed wheel capacities totalling approximately 430,000 horse power. The cost of carrying out this comprehensive plan was estimated at $81,368,000.

The Army Engineers are at present re-studying the comprehensive flood control plan, pursuant to the authorization of the 1936 Flood Control Act, and will submit at a later date a report on the results of their studies. As noted under the Flood Control section above, 15 reservoir sites have been selected by the Engineers as being best suited to development for flood protection in the entire valley.

The report of the Advisory Committee of Engineers on Flood Control, as summarized by the Public Service Commission of Vermont, contains the results of the investigations of its consulting engineer (H.K.Barrows), who made a study of the potential storage on the principal rivers of Vermont following the disastrous flood of November 1927. The report was in two parts: the first, completed in 1928, contained a report on the White and Passumpsic Rivers in the Connecticut basin, together with reports on three rivers in the Lake Champlain basin; the second, completed in 1930, covered the Nulhegan, Wells, Waits, Ompompanoosuc, Ottauquechee, Black, Williams and West Rivers.

In all, the two reports covered the 10 largest Vermont tributaries of the Connecticut. The purpose of the investigation was to determine the best methods for preventing disastrous floods on the Vermont rivers. The conclusion of the Engineer was that flood protection must rely fundamentally upon power-storage reservoir systems, because the cost of the protective works could not be justified on the basis of flood control benefits alone.

Out of the large number of reservoirs investigated, thirty-three were selected which would "increase the low water flow to a sufficient extent to make all of these streams dependable for power". The Report went on to say: "The development of power at and below reservoir sites can, in most instances, be accomplished at relatively low cost so as largely to carry the cost of the reservoir, and the resulting flood protection."

"It has been found possible to work out for each river system a comprehensive plan for storage and power development, including available head at reservoir sites as well as at other power sites upon the river below, that will provide power at reasonable cost; -- varying in general between about two-third cent and 1 cent per kilowatt hour and averaging about seven-eight cent for the entire area covered. In some instances a cost as low as one-half cent per kilowatt hour is possible, while a few rivers show costs exceeding 1 cent per kilowatt hour. These are costs of total power, of which approximately an average of 60% is primary power. To transform the secondary power into primary power will require make up or auxiliary power purchased or generated, which if included would make the cost of power, all primary, average approximately 1 cent per kilowatt hour, including all developments. This cost of output includes all fixed and operating charges for reservoirs and power developments, including land and property at present local prices but no allowance for special water rights."

The Report states that: "While it may be many years before all this power can be marketed, some of the more attractive projects can be used in the early future. The use of electric power, especially for domestic and farm purposes, is rapidly growing and a study made upon Windoski River by the U. S. Engineer Office indicates that a large part of the storage-power system proposed for that river will be needed within about 10 years.

"A general scheme of storage-power development has been planned for each river basin, which should be followed or kept in mind in all new developments."

With respect to the use of these reservoirs for the benefit of the plants on the Connecticut River the report stated that: "One of the significant results of the investigation was the importance of possible cooperation in sharing the cost of storage reservoirs for the eastern group of streams which are tributary to Connecticut River on the part of the plants upon the latter stream.

"As an illustration, the proposed Graysville reservoir upon White River, which of itself would largely solve the flood problem on that stream, with the river developed as proposed would have a head using this storage of 405 ft., and every million cubic feet of storage would cost $1.70 per foot of this 405 feet of head. On Connecticut River below White River is 245 ft., of head

mostly developed which if included to share the cost of storage would reduce the unit cost of storage from $1.70 to $1.06 per million cubic feet per foot of head.

"In general, the inclusion of Connecticut River cooperation will make this eastern group of streams capable of power-storage development at relatively low cost -- whereas without this cooperation some of these rivers show too costly developments to be attractive."

These thirty-three reservoirs would control a total drainage area of 2691 square miles, and would have a storage capacity, below spillway level, of 33,630,000,000 cubic feet (773,490 acre-feet). The resulting increase in low-water flow in the Connecticut below the West River would be about 1840 cubic feet per second. This would more than double the low-water flow at Turners Falls, Mass., where it is now only 1500 cubic feet per second. The corresponding increase in primary power on the Connecticut was estimated to be about 46,000 horsepower, at a cost of 0.6 cent per kilowatt-hour. The storage would provide also a material reduction in flood flows, inasmuch as approximately one-third of the total Connecticut drainage area would be effectively controlled.

The summarized data for these thirty-three reservoirs is given below:

Storage Capacity, below spillway	772,000 acre-feet
Storage Capacity, above spillway	268,000 " "
Total estimated cost	$37,988,000
Increase in Low Water Flow of Connecticut River below West River	1,842 c.f.s.
Developed Head on Connecticut River using storage	289 feet
Horse-power of Increased Low Water Flow	46,300 horse power
Cost allocated to Connecticut River Plants (total cost allocated on basis of head benefited)	$16,047,000
Cost of Increased Primary Power	0.57¢/ Kw.hr.

The Barrows Report on New Hampshire tributaries of the Connecticut River included results of investigation of power-storage regulation for the Ashuelot, Sugar, Mascoma, Ammonoosuc and Upper Ammonoosuc Rivers. The effect of such regulation upon the flow of the main river was also discussed. The Report recommended as feasible the development of twenty-one reservoir sites (including 5 then in use), controlling about 1157 of the 1551 square miles drained by the five tributaries. The total below-spillway capacity of the twenty-one reservoirs would be 14.2 billion cubic feet. At 14 of the reservoir sites, power could be developed under a total of 2690 feet of head; the installations would aggregate 53,000 horse power; the average yearly output would be about 172 million kilowatt-hours.

The Report indicated that at 25 additional sites, power could be developed under an aggregated head of 1794 feet, and with a wheel capacity of 78,000 horse power. If all 39 power sites were developed, the total head utilized would be 4484 feet; the total wheel capacity 131,000 horse power; and the annual output 409 million kilowatt-hours, of which 57% would be primary.

NEW ENGLAND WATER RESOURCES

RECOMMENDED PROJECTS

EXCEPT WATER SUPPLY AND POLLUTION PROJECTS

CONNECTICUT BASIN

DEC. 1 1937

SCALE

0 8 16 24 32

NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE — DISTRICT Nº 1
2100 FEDERAL BUILDING — BOSTON MASSACHUSETTS

Connecticut River plants would benefit by an increase in low-water flow of 385 cubic feet per second at Bellows Falls and Vernon, and 450 at Turners Falls. This would add an equivalent of 11,500 horsepower of 24-hour primary power, at a cost of about 0.54¢ per kilowatt-hour.

As an initial program five storage projects and four power developments were recommended. The reservoirs would control about 263 square miles of drainage area, and would cost, for storage alone, about $4,115,000. The 4 power developments, which would utilize 837 feet of head and develop 11,800 horsepower, would cost $1,202,000. With existing Connecticut River plants cooperating in the cost of storage, the average cost of total power at reservoir sites would be 0.58¢ per kilowatt-hour. Without such cooperation, the corresponding figures would be, respectively, 0.94¢ and 1.12¢ per kilowatt-hour. Hence, it is probable that the projects would not be developed economically unless part of the cost were borne by Connecticut River power plants.

Below may be found data for the initial group and for all 21 sites, as summarized from tables in the Consulting Engineer's Report:

	Initial Five	Twenty-One
Capacity, Below Spillway	119,000 acre-feet	326,000 acre-feet
Capacity, Above Spillway	51,000 " "	106,000 " "
Total Estimated Cost	$4,115,000	$11,317,000
Estimated Increase in low-water flow on Connecticut River	207 c.f.s.	448 c.f.s.
Total head using increased flow on the Connecticut River	533 ft.	533 ft.
Equivalent increase of power on Connecticut River	8,330 h.p.	11,500 h.p.
Cost allocated to Connecticut River plants (on basis of head)	$2,946,000	$3,961,000
Cost of increased primary power on Connecticut	0.58¢/Kw.-hr.	0.54¢/kw-hr.

Since the Barrows Reports of 1928 and 1930 were made, the Army Engineers made a report in 1935 embracing comprehensive studies of the Connecticut River basin as authorized by the H. D. 308 Act. A report in 1937 authorized by the Flood Control Act of 1936 was submitted. These studies embraced detailed surveys, geological investigations, and complete analyses of the various water problems of the Connecticut River. The result of these comprehensive investigations indicated: "that flood control reservoirs and other flood control measures were economically feasible; that the justification, therefore, does not require them to be part of a power development."

Navigation As a commercial thoroughfare the Connecticut has influenced New England's industrial history. During the late colonial period sloops and barks shipped cargoes from Hartford to coastal and foreign ports, while above Hartford flatboats plied the river. Cargoes must therefore be unloaded, carried and reloaded at each fall. After the Revolution the development of inland waterways received widespread attention. Locks and canals were built at South Hadley and Turner's Falls in Massachusetts; at Bellows Falls, Sumner Falls, and White River Junction, Vermont; and at Enfield, Connecticut. From Wells River, Vermont, to Hartford, Connecticut a 190-mile inland waterway was used by flatboats 70 feet long, 15 feet wide, and capable of carrying 30 to 40 tons. Connecticut River cities and towns bustled with industrial activity, engendered by inexpensive transportation.

With the advent of steam power, steamboats were placed in river service, but the locks were too small and the river depths too shallow to accommodate them. Conditions soon dictated the use of steamers as relay carriers shuttling between locks, were freight was unloaded and reloaded. The toilsome and time-consuming procedure, earlier applied to flatboat methods, had reappeared.

Although schemes were developed for the improvement of the Connecticut waterway, the rapid expansion of railroad systems made competition seem hopeless. The stampede of railroad extension cast a shadow, still remaining, upon navigation in the river.

Today the only type of transportation on the upper river is a small amount of log-driving, and an indication of the volume of traffic on the lower river (the most favorable section for river freight) is that in 1936 only 12 pleasure boats and no commercial vessels passed through Windsor Locks.

The Windsor Locks, constructed about 1830, permit passage around Enfield Rapids. The rapids are nearly 70 miles from Long Island Sound and the next water fall is at Holyoke, Massachusetts, 86 miles from the ocean. However, the limitations now imposed upon the size of freighters by the lock dimensions and shallow channel (controlling depth 2 feet at mean low water) prevents commercial use of the 34 miles from Hartford to Holyoke. According to the Army Engineers "the locks provided are 19.5 ft. wide with about 77 ft. of usable length and have 3 feet over the lower miter sill at low water."

Below Hartford the river is tidal for the 52 miles to the ocean. In this section the freight handled in 1936 amounted to 1,074,388 tons, nearly twice the amount ten years ago. The predominating commodity, formerly coal, is now petroleum. Under authorization of the Rivers and Harbors Act of 1935 the channel from the sea to Hartford, at the head of commercial navigation, has been dredged 15 feet deep and 150 feet wide, and training works have been constructed. The channel will be maintained at project depth by removing shoals caused by spring freshets.

The Engineers and local citizens have given serious consideration to possible extension of commercial navigation beyond Hartford to Holyoke, Massachusetts (34 miles). In 1930 Congress authorized $1,000,000 for a 12-foot channel between these cities, to be secured by constructing a dam and locks near Hartford; by lengthening the locks around Enfield Rapids; and by dredging. Construction was not to begin until local money was put up to build a satisfactory dam and locks at Enfield Rapids, and until other minor improvements were assured. Changes in the New England power market, since 1928, have rendered power plant construction at Enfield Rapids a financially dubious proposition until peak-power demands again exceed existing plant capacities. Careful estimates of potential annual tonnage and benefits from such improvement have been prepared for use in justifying the cost of the necessary works. Now a study of construction costs and power values is being made.

Erosion Soil erosion in the basin within the State of Connecticut is confined to moderate sheet erosion affecting less than one-tenth of the total area. The only two large areas are along the Coginchaug River south and west of Middletown and on the inner rim of the Connecticut valley, a few miles east of Thompsonville and Windsor Locks.

In Massachusetts there is evidence of several different types of erosion, affecting a total of about ten percent of the Connecticut basin in the state. There are areas of moderate sheet erosion with occasional gullying in Westfield and Southwick, and in Becket; along the railroad line between Greenfield and Hatfield there is a long narrow area of moderate sheet and slight wind erosion; and in the western part of the basin several small sections have been attacked by moderate sheet erosion. Early stages of sheet erosion and gullying occur throughout the northern Massachusetts portion of the basin.

The New Hampshire lands tributary to Connecticut River waters are free from erosion problems, except along the banks of the main river and larger feeders, where there is evidence of slight sheet erosion in several localities.

Although erosion has affected less than ten percent of the land in the Vermont section of the watershed, in most places where it does occur it has reached a fairly advanced stage. In southern Vermont scattered areas affected show moderate sheet erosion, while in two instances, in Weston and Windham, occasional gullying is manifest also. In central and northern Vermont there are narrow, scattered areas along stream banks where slight sheet erosion and occasional gullying is found. On the Second Branch of the White River there is a fairly large area of moderate sheet erosion and occasional gullying.

Stream bank erosion has been the source of material losses in the Connecticut valley. Fast currents coincident with high water stages, wave action, and occasionally ice tear away the banks above the low-water level. At some points the river undermines the banks by erosion below the low-water mark. During the time between flood stages vegetation grasps the opportunity to establish itself upon the banks. If sufficient time elapses this vegetation becomes a heavy growth of trees and large bushes which resists river currents. Such natural protection had grown along the Connecticut banks prior to the 1927 flood. But, in many places, this flood over-powered the growth and caused extensive bank erosion. Once protection is lost, subsequent high waters continue to carry away bank material. The recurrence in 1936 of an even greater flood stage swept away more bank vegetation and damaged the shores. Even though exceptional floods are not repeated, at least one or two decades will be required for Nature to replace the protection recently wiped out.

The undermining of river banks frequently occurs when a deep channel lies near the concave side of river bends. Two examples of this on the Connecticut are at Hadley and Northampton, Massachusetts. According to the Army Engineers, periodic observations at these points indicate the maximum rates of erosion to be, respectively, 13 and 12 feet per year.

Protective works often serve to prevent the flooding of low areas, as well as to check bank erosion. In the half century prior to 1935 over $900,000 had been spent for protection along the Connecticut in Massachusetts. Many of the Massachusetts towns above Springfield proposed, in 1934, new bank protection works or extensions of existing works. In 1935 Army Engineers

stated that the problems in Montague, Sunderland, Northfield and South Hadley appeared to be so great as to merit early attention. Bank protection is needed also at Agawam, Hadley, Hatfield, Holyoke, Northampton and Whately, Massachusetts, and at the outlet of the White River in Hartford, Vermont.

Drainage Except for the extensive tidal marshes along the Connecticut estuary, the only swamps are those at the headwaters of the major stream and its tributaries. There are occasional fresh-water swamps in the southern portion of the basin. Throughout central and northern New Hampshire and northern Vermont there are small swamps, which usually constitute the sources of streams. Long, narrow, swampy valleys characterize the basin in Canada and the extreme northern part of New Hampshire. About fifteen years ago consideration was given to drainage problems in the Massachusetts part of the valley, particularly at Greenfield, Deerfield and Brookfield. However, there are now no drainage problems in the Connecticut basin other than those of local significance for mosquito elimination or reclamation of residential land.

Recreation Hunting, fishing and other forms of commercial recreation provide part-time sources of income for many Connecticut Valley citizens. The Connecticut River headwaters and tributary lakes, ponds, and streams entice hordes of sportsmen, sightseers, and vacationists, but the natural attractions of the main river cannot be fully utilized because the main stream is used to such extent for industries and for waste disposal.

The sapping of recreational values which occurs when a picturesque brook or river is overloaded with domestic and industrial wastes has been experienced on several Connecticut River tributaries. The intensity of commercial recreation in all parts of the basin has already prompted serious consideration of such damage to recreational values, and some improvement, although spotty in character, has been achieved. Proper sanitary conditions in the streams will prove an economic benefit in the commercial recreation areas and also in the industrialized southern section of the basin. In the first instance, scenic playgrounds must be reasonably clean to attract visitors; in the latter instance, satisfactory opportunities for recreative activity near large population centers depend primarily on their proximity to clean ponds, lakes or streams.

The wildlife population in the northern section of the basin requires only a normal amount of supervision and protection to avoid excessive depletion, but in the more densely occupied southern section every opportunity to foster and preserve wildlife should be grasped. Except for extensive hunting and fishing and for normal suburban expansion, there are, at present, no indications of developments which will, in appreciable degree, affect wildlife anywhere in the basin.

TABLE III-E

SUMMARY OF STREAM FLOW RECORDS - CONNECTICUT BASIN

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
Connecticut River						
at Pittsburgh, N.H.	82	19	3,620	28	208	3,620
at No. Stratford, N.H.	798	6	28,000	50	1,600	28,400
near Dalton, N.H.	1,538	2	46,500	230	3,150	48,300
at Waterford, Vt.	1,600	9	46,500	155	3,070	48,300
at So. Newbury, Vt.	2,830	17	76,500	198	4,990	77,800
at Orford, N.H.	3,100	21(a)	56,000	288	5,460	57,300
at White River Junction, Vt.	4,070	25	129,000	540	7,300	148,000
at Turners Falls, Mass.	7,140	21	206,000	128	11,610	210,000
at Montague City, Mass.	7,840	35	233,000	597	13,530	236,000
at Holyoke, Mass.	8,284	19(b)	240,100	150	12,100	244,000
at Thompsonville, Conn.	9,637	8	278,000	1,310	15,440	282,000
Passumpsic River						
at Passumpsic, Vt.	423	8	15,400	10	733	16,000
Moose River						
at St. Johnsbury, Vt.	112	8	4,950	8	218	5,720
White River						
near Bethel, Vt.	241	5	8,500	28	467	12,200
at W. Hartford, Vt.	687	20	31,300	39	1,140	140,000
Mascoma River						
at Mascoma, N.H.	153	13	5,090	1.1	203	5,650
Ottauquechee River						
at No. Hartland, Vt.	221	6	13,300	3	380	30,400
Sugar River						
at W. Claremont, N.H.	270	8	11,200	6.5	343	14,000
Black River						
at No. Springfield, Vt.	158	7	10,100	11	266	14,700

(a) this station discontinued in 1921
(b) this station discontinued in 1899

SUMMARY OF STREAM FLOW RECORDS - CONNECTICUT BASIN

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
West River at Newfane, Vt.	310	12	24,000	19	573	53,100
Ashuelot River near Gilsum, N. H.	71	14	3,750	1	121	4,400
at Hinsdale, N. H.	420	24	16,500	.1	635	18,000
Otter Brook near Keene, N. H.	42	13	1,950	2	67	3,580
South Branch of Ashuelot River at Webb near Marlboro, N. H.	37	16	2,070	0	60	3,880
Millers River near Winchendon, Mass.	80	19	4,740	0	138	5,530
at Erving, Mass.	373	22	18,800	0	617	19,700
Sip Pond Brook near Winchendon, Mass.	19	20	1,080	0.1	29.8	1,430
Priest Brook near Winchendon, Mass.	19	19	---	0.1	32.8	1,840
East Branch of Tully River near Athol, Mass.	50	20	3,030	0.2	84.5	3,700
Moss Brook at Wendell Depot, Mass.	12	20	922	0.8	21.7	1,300
Deerfield River at Charlemont, Mass.	362	23	21,700	0	872	50,600
Ware River at Cold Brook, Mass.	98	8	3,600	5	150	6,000
at Gibbs Crossing, Mass.	199	24	9,890	5	310	11,200
Chicopee River at Bircham Bend, Mass.	703	8	18,900	0	959	20,400
Swift River at West Ware, Mass.	186	26	6,850	8.5	298	7,590
Quaboag River at West Brimfield, Mass.	151	27	3,510	2.5	230	3,620

SUMMARY OF STREAM FLOW RECORDS - CONNECTICUT BASIN

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
Westfield River						
at Knightville, Mass.	162	27	13,400	4	317	25,700
near Westfield, Mass.	496	22	31,500	9	901	48,200
Middle Branch - at Goss Heights, Mass.	53	26	4,610	0	103	8,400
Westfield Little River near Westfield, Mass.	48	31	3,790	0	94	6,100
West Branch Westfield, at Huntington, Mass.	93.7	1	7,640	8	192	14,400
Scantic River						
at Broad Brook, Conn.	99	8	1,540	17	113	1,620
Farmington River						
near New Boston, Mass.	93	23	5,960	5.7	179	9,080
at Riverton, Conn.	217	7	12,800	17	345	19,900
at Tariffville, Conn.	569	8	20,300	124	797	22,200
Burlington Brook						
near Burlington, Conn.	4.1	5	254	0.81	7.1	503
Hockanum River						
near East Hartford, Conn.	75	8	1,290	1.2	104	15,300
Salmon River						
near East Hampton, Conn.	105	8	4,750	1	153	6,250

TABLE IV

EXPLANATORY NOTES
Concerning the table of
SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

Column 1. Town or City. Municipalities, arranged alphabetically, where available information positively indicated the existence of an organized sewerage system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 Census.

Column 3. Population Served. Best available estimate of the persons served by an organized system.

Column 4. Discharge in thousand gallons per day. The best available estimate of the volume of sewage discharged.

Column 5. Treatment. Abbreviations, noted below, indicate the type of treatment applied to the domestic wastes.

Column 6. Chief sources of Industrial Wastes. The industries which commonly pollute streams are indicated by concise reference to the type of plant, product or raw material.

Symbols

---	No information available
(P)	Partial
(s)	Summer resort.
(S)	State Institution
(U)	College or University
Various	Several industries present with none clearly predominant.
Milk	Refers to pasteurizing, ice cream and dairy plants.
Fert.	Fertilizer factory.
Oil	Petroleum products; storage or distribution plants.
Gas	Illuminating gas manufacturing plant.
Cannery	Includes fish packing.

Im.	Imhoff Tank	A.	Aeration.
Sp.	Septic Tank	Cl.	Chlorination
SF.	Sand filtration.	St.	Settling
F.	Filtration.	Sc.	Screening (fine)
CP.	Cesspool	Br.	Barging sludge to sea.
Sl.	Sludge treatment.	Sm.	Sedimentation
AcSl.	Activated sludge plant.	Ir.	Irrigation

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments

TABLE IV-E

SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

CONNECTICUT BASIN

Town or City	Domestic Sewage: Population 1930	Population Served	Discharge thous. gal/day	Treatment	Industrial Wastes Chief Sources
Bethlehem, N.H. (s)	872	8000	20	none	---
Charlestown	1644	653	46	none	---
Claremont	12377	4000	840	none	---
Colebrook	1937	1500	---	none	---
Hanover	3043	4500 (U)	643	none	---
Haverhill	3665	2200	666	none	---
Hinsdale	1757	---	---	none	---
Keene	13794	10000	920	Im.	---
Lancaster	2887	2000	208	none	---
Lebanon	7073	5000	400	none	---
Lisbon	2324	1500	150	none	---
Littleton	4558	3000	500	none	---
Newport	4659	4500	562½	none	---
Northumberland	2360	1500	207½	none	---
Stratford	918	500	---	none	---
Walpole	2287	1000	18	none	---
Whitefield	1693	1500	127½	none	---
Barnet, Vermont	2604	88	---	none	Milk
Bethel	1650	550	---	none	Milk
Bradford	1237	300	---	none	Milk
Brattleboro	9816	9000	900	none	Milk
Burke	1016	140	---	none	---
Canaan	906	422	---	none	---
Danville	1600	30	---	none	Milk
Fairlee	456	80	---	none	Milk
Guildhall	351	40	---	none	---
Hartford	4888	2865	200	none	Woolens
Ludlow	2395	2100	---	none	Woolens
Lunenberg	1400	1000	---	none	Paper
Lyndon	3285	1200	---	none	Milk
Newbury	1744	420	---	none	Paper
Norwich	1371	67	---	none	---
Randolph	3166	1900	---	none	---
Readsboro	1043	300	---	none	---
Rochester	1285	250	---	none	Milk
Rockingham	5302	3250	300	none	Paper and Milk
Royalton	1491	410	---	none	---
St. Johnsbury	9696	6000	600	none	Gas
Springfield	6955	4000	400	none	Woolens
Tunbridge	903	35	---	none	---
Wilmington	1171	400	---	none	---
Windsor	4359	3000	300	none	---
Woodstock	2467	1500	---	none	---

CONNECTICUT BASIN (cont'd)

Town or City	Domestic Sewage: Population 1930	Domestic Sewage: Population No. of Services	Domestic Sewage: Discharge thous. gal/day	Domestic Sewage: Treatment	Industrial Wastes: Chief Sources
Amherst, Mass.	5888	--	--	Sm.	--
Athol	10677	--	470	none	Artificial leather
Chicopee	43930	--	--	none	Rubber
Deerfield	2882	--	13	none (1)	--
Easthampton	11323	1268	569	Sm. SF.	--
Gardner	19399	2580	880	Sd. SF.	Stoves
Greenfield	15500	--	1382	none	--
Hardwick	2460	--	5	none	Pulp
Hatfield	2476	--	--	none	--
Holyoke	56537	--	7365	none	--
Huntington	1242	--	--	none	Clothing
Longmeadow	4437	--	212	none	--
Ludlow	8876	--	325	none	Woolens
Montague	8081	--	700	none	--
Northampton	24381	--	--	none	--
North Brookfield	3013	--	--	F. Ir.	Rubber Goods
Orange	5365	--	23	none	Metal Goods
Palmer	9577	--	19	none	Wire, Milk, Textiles
South Hadley	6773	--	--	none	--
Spencer	6272	--	--	SF.	Shoes
Springfield	149,900	--	14000	none	Plastics
Ware	7385	--	--	none	Textiles
Westfield	19775	--	1693	none	Various
West Springfield	16684	--	1806	none	Paper
Winchendon	6202	448	17	Sm. SF.	Textiles

(1) Treatment plant under construction.

CONNECTICUT BASIN (cont'd)

Town or City	Population 1930	Domestic Sewage Discharge Served	Discharge thous. gal/day	Treatment	Industrial Wastes Chief Sources
Avon, Connecticut	1738	80	8	Sp.SF.	--
Bristol	28451	20000	1600	SF.	Metals
East Hartford	17125	13000	1300	none	Airplane parts
Enfield	13404	9000	900	none (1)	Woolens
Farmington	4548	1115	200	none	Paper
Granby	1388	60	6	Sp.	--
Hartford	164,072	170,500	20000	none (1)	Various
Manchester	21973	19000	2400	Sp.Sm.Sl.	Paper and Silks
Middletown	24554	26500	1900	Im.Sl.20% (1)	Various
New Britain	68128	35000	5500	Sc.F.Sl.	Various
Newington	4572	600	60	Im.Sl.SF.	Plumbing Supplies
Portland	3930	2000	200	none	Oils
Rocky Hill	2021	70	7	Im.Sl.	Silks
Simsbury	3625	1900	190	Sm.SF.Sl.	--
Vernon	8703	8000	2100	Sc.Sm.Sl.	Woolens and Gas
West Hartford	24941	23000	3000	none (2)	--
Wethersfield	7512	4500	450	Sp. 80%	--
Windsor	8290	4500	450	none	Paper
Windsor Locks	4073	3000	300	none	Paper and Cotton

(1) Treatment plant under construction, Sm.F.Sl.
(2) Constructing outlet for discharge into Hartford system.

Plainville	6,301	240	24	Sp.SF.	Plating & electric

EXPLANATORY NOTES
concerning tables of the
ORGANIZED WATER SUPPLY SYSTEMS

Column 1. Town or city. Municipalities, arranged alphabetically, where available information indicates the existence of an organized public or semi-public water supply system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 census.

Column 3. Population Served. Best available estimate of the persons served by an organized system (as for the year 1936).

Column 4. Consumption in thousand gallons per day. Best available estimate of the normal daily requirement.

Column 5. Sources of supply. The type of source drawn from is indicated by symbols:- R. for Reservoir, Pond or Lake; W. for Wells, either deep or shallow; Spr. for Spring; Str. for Streams.

Column 6. Watershed area in square miles. Best available estimate of the drainage area upon which the water supply is dependent.

Column 7. Capacity in millions of gallons. Best available estimate of the quantity of water stored by, or immediately available to, the municipal supply.

Column 8. Type of Treatment. Available information concerning the methods used to improve the quality of the water served.

SYMBOLS

(2), etc. Numerals enclosed in parentheses indicate the number of separate water supply systems which serve the municipality. Where there is only one system no symbol is necessary.

(S) Includes State institution
(T) Includes Summer population served
(U) Includes College or School
(s) Provides Summer service only
(a), (b), etc. Letters enclosed in parentheses link civil divisions served by the same water source:-
In column 3 and 4 they link municipalities where available information does not give the number served in each town.
In column 5 letter indicates that the civil division imports water.
In column 6 and 7 letter indicates that the civil division exports water.
Letters link municipalities within one state and basin; cross-references between basins or states appear in footnotes.

Symbols (continued)

A.	Aeration	K.	Activated carbon
Al.	Alum	L.	Lime
AlSl.	Aluminum sulphate	MF.	Mechanical filter
Am.	Ammonia	PF.	Pressure filter
AmSl.	Ammonium sulphate	pH.	Correction of reaction
AS.	Alum - Soda Ash	RF.	Rapid filter
CC.	Corrosive correction	S.	Soda ash
Cl.	Chlorine	SF.	Slow filter
Co.	Coagulation	Sm.	Sedimentation
CuSl.	Copper sulphite	SoCl.	Sodium hypochlorite
F.	Filter	St.	Storage of protective significance.
IR.	Iron removal		

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments
Annual Reports, Public Utilities Commissions

Table V-E

ORGANIZED WATER SUPPLY SYSTEMS

CONNECTICUT RIVER BASIN

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal	Type of treatment
Bath, New Hampshire	735	100	5	W.	--	--	--
Bethlehem	872(T)	1,500	500	Str.	--	1.25	--
Canaan	1,301	800	80	R.	--	--	--
Carroll	402(T)	1,300	130	Str.	--	.01	--
Charlestown (2)	1,644	1,125	78	Str.	--	--	--
Claremont (2)	12,377	10,000	700	Str. & Spr.	--	70.	Cl. (P)
Colebrook	1,937	1,500	200	W. & Str.	--	1	Cl.
Enfield	1,325	--	--	Str. & R.	--	--	--
Franconia	514	450	25	Spr.	--	--	--
Hanover (2)	3,043	4,500(U)	500	Str. & R.	--	300	--
Haverhill (3)	3,665	2,250	210	Str.R.Spr. & W.	--	2	Cl. (P)
Hinsdale	1,757	1,200	120	Str. & R.	1.6	70	SF.Cl.
Jefferson	771	100	5	Spr.	--	--	--
Keene	13,794	13,000	1,200	R.	1.9	440	SF.
Lancaster	2,887	2,112	220	Str.	--	2	--
Lebanon (2)	7,073	7,000	670	Str.	--	237	MF.100%; Cl.70%
Lisbon	2,324	1,200	120	R.	5.	.75	Cl.
Littleton	4,558(T)	5,000	700	Str.	--	1.9	Cl.
Lyme	830	200	70	Spr.	--	.03	--
Marlborough	1,508	1,200	126	Spr.	--	.05	--
Newbury	333(T)	550	54	R.	--	.01	--
Newport	4,659	4,000	500	R.	1.	170	--
Northumberland	2,360	2,000	210	Str.	--	.6	--
Pittsburg	671	300	30	Spr.	--	--	--
Plainfield	858	200	6	Str.	--	.05	--
Stewartstown	1,148	400	35	Spr.	--	--	--
Stratford	918	700	77	Str.	--	2	--
Sunapee	1,040(T)	1,500	135	R.	45.1	6400	Cl.
Surry	198	--	--	Spr.	--	--	--
Swanzey	2,066	1,000	100	Spr.	--	--	--
Troy	1,267	700	70	Str.	--	--	--

Table V-E

ORGANIZED WATER SUPPLY SYSTEMS

CONNECTICUT RIVER BASIN (continued)

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal	Type of treatment
Walpole, New Hamp.(2)	2,287	1,900	130	Str.W.& Spr.	—	..1	SF.(P)
Whitefield	1,693	1,175	100	Str. & W.	—	1	—
Barnet, Vermont(3)	2,604	235	—	Spr.	—	—	—
Bethel	1,650	600	40	Spr.	—	—	—
Bradford	1,235	425	60	R.	.3	1.	none
Brattleboro	9,816	9,000	1,000	R.	2.6	229.	Cl.
Canaan	906	215	—	Spr.	—	—	—
Chester	1,666	1,200	—	Spr.	—	11.	—
Danville (3)	1,600	361	—	R. & Spr.	—	—	—
Fairlee (2)	456	335	—	Spr.	—	—	—
Guildhall	351	145	—	R.	—	—	—
Hartford (6)	4,888	3,135	379	Spr. & R.	1.2	30.09	—
Ludlow	2,305	2,100	—	Spr.	—	$1\frac{1}{2}$	—
Lyndon (2)	3,285	1,400	—	R.	—	—	—
Newbury (2)	1,744	925	27	R. & W.	—	.12	—
Norwich (2)	1,371	350	5	R.	—	—	—
Peacham	620	204	—	Spr.	—	.075	—
Randolph	3,166	1,900	250	R.	2	1	none
Readsboro	1,043	300	—	R.	—	—	—
Rochester	1,285	280	120	R.	—	.1	none
Rockingham (3)	5,302	3,295	302	R. & Spr.	—	—	—
Royalton (2)	1,491	650	7	Spr.	—	.0075	—
St. Johnsbury (2)	9,696	6,610	1,500	R.	9	640	SF.
Springfield (2)	6,955	4,357	451	R. & Spr.	3.6	56	none
Thetford	1,052	110	—	Spr.	—	—	—
Tunbridge	903	80	—	Spr.	—	—	—
Wilmington	1,171	400	—	R.	—	.14	none
Windsor	4,359	3,000	550	Spr.	—	.5	—
Woodstock	2,469	1,500	355	R.	—	9	—

Table V-L

ORGANIZED WATER SUPPLY SYSTEMS

CONNECTICUT RIVER BASIN (continued)

Town or city	Pop. 1930	Services	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal	Type of treatment
Agawam, Mass.	7,095	1,500	343	(a)	—	—	Sm.Co.A.SF.Cl.
Amherst	5,838	1,492	577	R.	14	243	Cl.
Ashfield	860	92	—	R.	.5	5	—
Athol	10,677	1,895	622	R.	8	223	Co.MF.(15%), SF.(45%)
Barre	3,510	225	—	R.	.4	12	none
Belchertown	3,139	160	28	W.	—	—	—
Bernardston	893	—	—	(b)	—	—	—
Blandford	545	113	—	R.	.14	.8	none
Brookfield	1,352	—	—	R. & W.	.1	2.6	Cl.(P)
Charlemont	816	—	—	Str.	—	—	none
Chester	1,464	—	—	R.	.07	40	none
Chicopee	43,930	6,208	3,554	R.	5	135	A.Co.Sm.RF.(99%)Cl.
Colrain (3)	1,391	—	—	Spr. R.& W.	.8	.4	Cl. (P)
Cummington	531	—	—	W. & Spr.	—	—	none
Deerfield (2)	2,882	150	—	R. W. & Spr.	4	1.5	Cl. (P)
East Brookfield	926	137	32	W.	—	—	none
Easthampton	11,323	1,575	844	W.	—	—	none
East Longmeadow	3,327	590	88	(a)	—	—	Sm.Co.A.SF.Cl.
Erving	1,263	—	(c)	(c)	—	—	none
Gardner	19,399	2,930	883	R. & Str.	3.7	466	Cl.
Gill	933	74	—	Spr.	—	—	none
Granville	674	20	—	W. & Spr.	—	—	none
Greenfield	15,500	5,500	1,382	R.	5.4(b)	70(b)	Co.Sm.SF.Cl.
Hadley	2,682	320	—	R.	.5	2.5	none
Hardwick (3)	2,460	—	—	W.	—	—	—
Hatfield	2,476	450	—	R.	.3	1.6	none
Holyoke	56,537	6,137	7,365	R.	24.1(e)	3075(e)	none
Huntington	1,242	—	—	R. & W.	.9	1.3	none
Longmeadow	4,437	1,330	212	(a)	—	—	Sm.Co.A.SF.Cl.
Ludlow	8,876	841	325	R.	21.1(d)	2000(d)	SF. (P)

Table V-E

ORGANIZED WATER SUPPLY SYSTEMS

CONNECTICUT RIVER BASIN (continued)

Town or city	Pop. 1930	Services	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal	Type of treatment
Monroe, Massachusetts	218	--	--	R. & Spr.	.9	.05	none
Monson	4,918	572	--	W. Str. & R.	6.3	30	none
Montague (4)	8,081	968	812(c)	R. & Spr.	1.8(c)	167 (c)	none
Northampton	24,381	4,350	--	R.	19	444	Cl. (P)
Northfield(3)	1,883	113	--	R.	.9	26	--
North Brookfield	3,013	590	337	R.	2	404	none
Orange	5,365	--	--	R. & Spr.	1.4	2	none
Palmer (6)	9,577	1,050	--	R. Spr. & W.	.6	19.8	Cl. (P)
Paxton	672	--	--	Spr.	--	--	--
Russell	1,237	97	--	R. & W.	3.2	1	Cl.
Rutland	2,442	189	220	R. & (f)	.6(g)	464.5(g)	Cl.
Shelburne	1,544	490	85	R.	1.5	12.5	none
Southampton	931	--	--	(e)	--	--	--
Southwick	1,461	117	25	(a)	--	--	Sm.Co.ASF.Cl.
South Hadley (2)	6,773	378	--	R. & W.	1.1	34	Cl.SF. (P)
Spencer	6,272	960	--	R.	.6	--	none
Springfield	149,900	--	14,145	R. & (d)	102 (a)	79 (a)	Sm.Co.A.SF.Cl.
Sunderland	1,159	124	--	R.	.4	.25	none
Ware	7,385	1,037	369	W.	--	--	CC.
Warren (2)	3,765	375	83	W.	--	--	none
West Brookfield	1,255	235	62	W.	--	--	none
West Springfield	16,684	--	1,806	R.	5.05	65	A.SF.Cl.
Westfield	19,775	3,184	1,693	R.	17.15	837	Cl. (P)
Westhampton	374	25	--	R.	.6	.036	none
Whately (2)	1,136	--	--	Spr.	--	--	none
Wilbraham	2,719	259	45	(a)	--	--	SF.
Williamsburg	1,891	372	--	R.	.9	9.6	none
Winchendon	6,202	1,236	--	W.	--	--	none
Worthington	485	36	--	Spr.	--	--	none

Note: (f) Metropolitan Water Supply, see Boston, Mass. Coastal Basin (g) See Holden Water Supply, Merrimack Basin

Table V-E

ORGANIZED WATER SUPPLY SYSTEMS

CONNECTICUT RIVER BASIN (continued)

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal	Type of treatment
Avon, Connecticut(3)	1,738	1,415	84	W.(a-38%;b-10%)	--	--	Co.PF.38%;Cl.10%
Berlin (4)	4,875	2,310	179	(c-96%;d-4%)	--	--	Cl.
Bloomfield	3,247	1,500	125	(a)	--	--	A.SF.
Bristol	28,451	30,000	1,475	R.	7.8	610	Cl.
Burlington	1,082	130	5	(a)	--	--	Co.PF.
Canton	2,397	1,530	58	(a)	--	--	Co.FF.
Chester	1,463	1,100	83	R.	1.3(e)	193(e)	none
Cromwell	2,814	1,500	105	R.	.6	1.5	Cl.
Durham (2)	1,044	300	13½	W. Spr. & R.	1.1	.025	Cl. 37%
East Hartford	17,135	16,800	1,645	R.	10.4(f)	37 (f)	Cl.
East Windsor (2)	3,815	2,200	102	W.(g-62%)	--	--	Cl.62%
Ellington (2)	2,253	1,050	64	Str.(h-72%)	.7	--	Cl.72%
Enfield (2)	13,404	11,050	452½	R. & W.	.8(g)	2.6(g)	Cl. 85%
Essex	2,777	2,000	160	(e)	--	--	none
Farmington (2)	4,543	2,435	307	R.	1.2(b)	43.3(b)	SF.36%;Cl.100%
Glastonbury (3)	5,783	4,410	394	R. (f-36%)	.7	9	Am.4%; Cl.100%
Granby	1,388	200	12	Str.	6.3	--	none
Hartford	164,072	170,700	13,950	R.	88.7(a)	32371 (a)	A. SF.
Hebron	879	105	6	W.	--	--	none
Manchester (5)	21,973	19,215	952	W.R.(f-½%)	8.2	307.4	A.Co.Sm.RF.41%; Am.83%; Cl.99%
Middlefield	1,204(T)	215	14	W.	--	--	none
Middletown	24,554	18,000	1,635	R.	3.1	631	Cl.
New Britain	68,128	70,000	4,680	R. & W.	10.1(c)	1594(c)	Cl.
New Hartford (2)	1,834	1,500	90	R.	2.4	2.8	Cl. 47%
Newington (3)	4,572	4,450	367½	(a-99%; c-1%)	--	--	A.SF.99%;Cl.1%
OldSaybrook	1,643	235	18	(See Old Saybrook, W. Conn. Coas. Basin)			Cl.
Plainville (2)	6,301	2,530	89	(c-2%)(See W. Conn. Coas. Basin)			Cl. 2%
Plymouth	6,070	3,300	171	(R.&W. in Hous. Bas.)			none
Portland	3,930	3,500	225	R.	3.3	60	Cl.
Rocky Hill	2,021	1,500	135	(a)	--	--	A.SF.

Table V-E

ORGANIZED WATER SUPPLY SYSTEMS

CONNECTICUT RIVER BASIN (continued)

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal	Type of treatment
Saybrook, Conn.	2,381	1,800	144	(e)	—	—	none
Simsbury (4)	3,625	1,625	131½	Str.R. & Spr.	3.9	58	A.Co.Sm.RF.30%; Cl.88%
Somers	1,917	250	15	Str. Spr. & W.	.8	.02	SF.
South Windsor	2,535	100	10	(f)	—	—	Cl.
Suffield	4,346	2,600	106	R.	.8(j)	2.58(j)	Cl.
Tolland (2)	1,064	200	13	R.(h-31%)	.8	—	Cl.31%
Vernon	8,703	7,200	750	R.	15 (h)	4000(h)	Cl.
West Hartford	24,941	29,000	2,370	(a)	—	—	A. SF.
Wethersfield	7,512	8,000	655	(a)	—	—	A. SF.
Winchester	8,674	8,000	1,805	R. & Str.	12.2	583	Cl.
Windsor	8,290	8,100	660	(a)	—	—	A. SF.
Windsor Locks	4,073	3,000	122	(j)	—	—	Cl.
Meriden				Exported R.	3.1(d)	640(d)	Cl.

TABLE VI-E

EXISTING WATER POWER - CONNECTICUT BASIN

RIVER	NO. OF PLANTS IN				CAPACITY OF PLANTS OF			CAPACITY USED FOR		TOTAL CAPACITY
	N.H.	Vt.	Ms.	Ct.	over 10,000 HP.	1,000 to 9,990 HP.	under 1,000 HP.	Utility	Mfg.	Horse power
CONNECTICUT	60	64	82	54	606,000	153,395	54,984	647,020	167,359	814,379
Main Stream	10	0	8	6	459,400	40,845	1,199	430,820	70,624	501,444
Passumpsic	0	12	0	0	0	3,540	3,055	5,530	1,065	6,595
Wells	0	4	0	0	0	0	1,280	930	350	1,280
Ammonoosuc	6	0	0	0	0	0	2,100	1,250	850	2,100
White	0	7	0	0	0	0	1,520	740	780	1,520
Mascoma	12	0	0	0	0	2,000	2,200	2,590	1,610	4,200
Ottauquechee	0	6	0	0	0	0	1,685	300	1,385	1,685
Sugar	14	0	0	0	0	2,280	5,500	2,370	5,410	7,780
Black	0	17	0	0	0	2,250	4,060	2,950	3,360	6,310
West	0	6	0	0	0	0	1,355	1,060	295	1,355
Ashuelot	12	0	0	0	0	2,400	3,670	3,160	2,910	6,070
Millers	0	0	24	0	0	3,500	5,190	3,570	5,120	8,690
Deerfield	0	4	10	0	90,600	39,450	1,437	130,800	687	131,487
Chicopee	0	0	24	0	0	44,050	3,490	9,290	38,250	47,540
Westfield	0	0	16	0	44,000	5,680	3,110	44,350	8,440	52,790
Scantic	0	0	0	4	0	0	1,370	0	1,370	1,370
Farmington	0	0	0	13	12,000	7,400	3,103	5,280	17,223	22,503
Hockanum	0	0	0	16	0	0	3,556	0	3,556	3,556
Salmon	0	0	0	12	0	0	2,545	710	1,835	2,545
Others	6	8	0	3	0	0	3,559	1,320	2,239	3,559

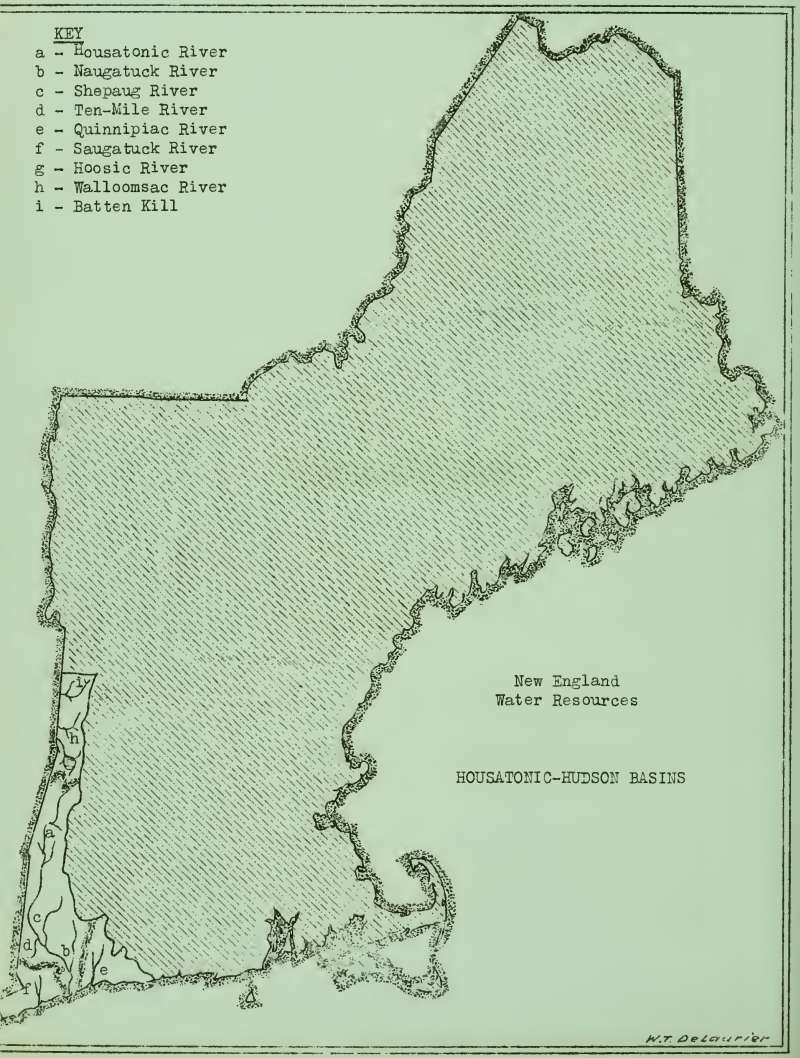
TABLE VII-E: EXISTING STORAGE

CONNECTICUT BASIN

	Drainage Area Sq.Mi.	Water Surface Sq.Mi.	Storage Capacity Acre-feet	Storage Equivalent Inches of Runoff
Connecticut Lakes	82	6.4	88,300	20.7
Lower 15 Mile Falls	1,659		33,000	0.4
Goose Pond	15	.9	11,000	
Mascoma Lake	148	1.7	11,400	3.7
Sunapee Lake	46	6.4	19,800	8.1
Somerset Reservoir	30		62,000	
Harriman Reservoir	184		116,000	18.2
Cobble Mt. W.S.Reservoir	45		62,000	
Otis Reservoir	17.6	1.7	18,400	19.6
Compensation Reservoir	61		9,200	2.8
Nepaug W.S.Reservoir	112		29,000	
Estimated Total, existing	11,320		500,000	0.83
Quabbin W.S.Reservoir (Under Construction)	187		274,000	
Pittsburgh Reservoir (Under Construction)	166	3.2	98,500	21.1

NOTE: Storage equivalent, in inches of runoff, is computed on a basis of all storage above point in question.

HOUSATONIC-HUDSON BASINS


KEY
a - Housatonic River
b - Naugatuck River
c - Shepaug River
d - Ten-Mile River
e - Quinnipiac River
f - Saugatuck River
g - Hoosic River
h - Walloomsac River
i - Batten Kill
New England
Water Resources
HOUSATONIC-HUDSON BASINS
W.T. DeLaurier

HOUSATONIC BASIN

GENERAL DESCRIPTION

The Housatonic basin has a total area of 1950 square miles, of which 500 square miles are in Massachusetts, 1235 in Connecticut, and 215 in New York. The basin is about 100 miles long from north to south and its maximum width is about 45 miles.

The river rises in western Massachusetts and flows north through Hinsdale to Dalton, southwest to Pittsfield, and thence south, crossing the Massachusetts--Connecticut line about 83 miles above its mouth. It empties into Long Island Sound between Milford and Stratford, Connecticut, about 4 miles east of Bridgeport. Of the total length of 150 miles, the lower 13 miles are tidal.

The northern part of the river's course is through a steep, narrow valley in high, irregular country. The valley broadens in southern Massachusetts, where the course of the river is decidedly meandering, and then narrows again in northern and central Connecticut. The lower portion of the basin is rolling country except for the comparatively flat coastal plain near the Sound. In general the hills rise to altitudes of about 1000 feet above the floor of the valley; the highest peak, at the northern end of the watershed, has an elevation of 2660 feet.

Rock formation is almost entirely granite, covered with coarse sand and gravel, except for occasional deposits of alluvial soil, particularly in the broad valley in Massachusetts. Nearly one-third of the total area is in cleared farmland, the major portion of which is pasture. The hilltops and ridges are generally well covered with mixed hardwoods, usually second or third growth.

The rainfall in the watershed averages about 44 inches annually, varying from 42 inches in the northern portions to over 47 inches near the coast. The monthly distribution of rainfall is fairly uniform, with somewhat higher amounts occurring in the latter part of the summer. Temperatures vary widely between the northern and southern parts of the basin, ranging from 20° to 30° in the winter and from 64° to 70° in the summer.

The principal tributaries of the Housatonic are the Naugatuck, Pomperaug, Shepaug and Ten Mile Rivers.

The Naugatuck rises in the northern part of Litchfield County, Connecticut and flows in a southerly direction for about 52 miles to its confluence with the Housatonic, at Derby, 12 miles above the mouth. Its drainage area is

312 square miles. As the valley is steep and rugged, the land along the river is not well suited to farming. There are, however, many industrial developments in the valley.

The Pomperaug rises near Bethlehem, in Litchfield County, and flows southeast for 17 miles to its junction with the Housatonic. Its drainage area is about 90 square miles. The river valley at the headwaters is broad but becomes narrow and steep at its lower end. The most populated portion of the basin is in the Woodbury--Southbury region, where there is good farmland. There are practically no industries in the valley.

The headwaters of the Shepaug are immediately west of those of the Naugatuck. The river is about 37 miles long and drains an area of 156 square miles. The topography of the basin is moderately rugged, becoming increasingly so in the lower part of the valley. The valley itself is narrow and steep, the average slope being 30.5 feet per mile. About 40 square miles, at the headwaters, arecontrolled for the water supply of Waterbury, in the Naugatuck valley.

The Ten Mile River valley lies almost wholly in New York, with 173 square miles out of the total area of 210 square miles in that state. The river rises in Dutchess County, New York. It flows south in that state to South Dover, where it turns abruptly to the east and enters the Housatonic about one mile east of the Connecticut-New York State line. The river winds for about 34 miles through rolling and wooded country of primarily recreational importance.

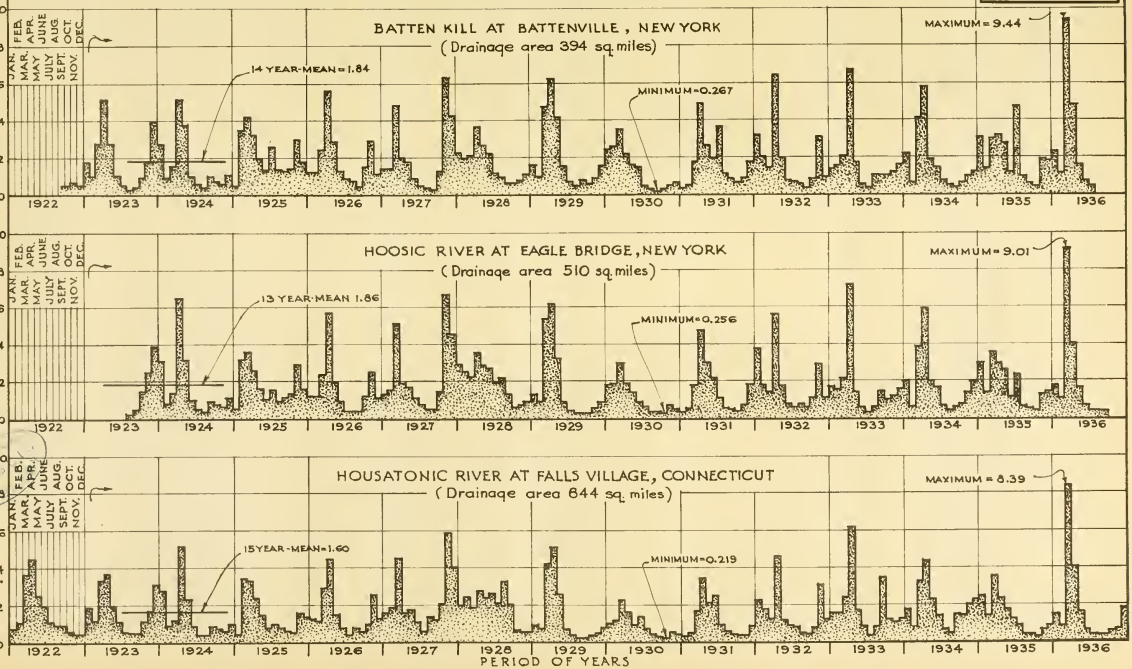
Discharge records are kept on the Housatonic and its tributaries by the U. S. Geological Survey in cooperation with the states of Massachusetts and Connecticut. Detailed data for these stations can be found in the U. S. Geological Survey Water Supply Papers, Part I - North Atlantic Slope Basins. The figures in Table III-F are summarized from unpublished records in the offices of the District Engineers at Hartford and Boston, and from the published papers of the survey.

The hydrograph on Chart 14 shows the monthly average run-off during the last 15 years of record at Falls Village, Connecticut. The average yearly runoff from the drainage area of 644 square miles above this point is 1.60 cubic feet per second per square mile.

MONTHLY HYDROGRAPH FOR REPRESENTATIVE STATIONS: HOUSATONIC, HOOSIC* AND BATTEN KILL*

(*HUDSON TRIBUTARIES)

CHART Nº 14


BATTEN KILL AT BATTENVILLE, NEW YORK
(Drainage area 394 sq. miles)
MAXIMUM = 9.44
14 YEAR-MEAN = 1.84
MINIMUM = 0.267
HOOSIC RIVER AT EAGLE BRIDGE, NEW YORK
(Drainage area 510 sq. miles)
MAXIMUM = 9.01
13 YEAR-MEAN 1.86
MINIMUM = 0.256
HOUSATONIC RIVER AT FALLS VILLAGE, CONNECTICUT
(Drainage area 644 sq. miles)
MAXIMUM = 8.39
15 YEAR-MEAN = 1.60
MINIMUM = 0.219
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932 1933 1934 1935 1936
PERIOD OF YEARS

DISCHARGE-CUBIC FEET PER SECOND PER SQUARE MILE

HUMAN OCCUPANCY

Population The population of the Housatonic watershed in 1930 was 370,000; divided between Connecticut, 285,000; Massachusetts, 76,000; and New York, 9000. The southern third of the basin, containing sixty percent of the entire population, has an average density of approximately 375 per square mile, in contrast to about 108 per square mile for the northern portion and 333 for the entire state of Connecticut.

The southern portion of the basin, largely urban, is included in the Bridgeport, Waterbury and New Haven metropolitan districts. Cities having over 10,000 population in 1930 are:

Waterbury,	Conn.	99,902
Torrington,	"	26,040
Danbury,	"	26,955
Ansonia,	"	18,898
Naugatuck,	"	14,315
Stratford,	"	19,212
Derby,	"	10,788
Shelton,	"	10,113
Pittsfield,	Mass.	49,677

Parts of Torrington and Stratford are in the Connecticut and the Western Coastal basins, respectively. All of these communities are important manufacturing centers. Waterbury is a trading center for much of the Housatonic valley in Connecticut, and Pittsfield for most of it in Massachusetts.

Increase in the population of the Housatonic basin was about 12.1% between 1920 and 1930, compared with an increase in the state of Connecticut of 16.4%. The location of cities and towns having gains or losses is shown on Map 7. The most consistent growth occurred in the southern urbanized section, while the losses were in the northern and western sections, where population density is low. Of the cities above 10,000 in population only two (Derby and Naugatuck) lost in the 1920-1930 decade. The important manufacturing communities, Waterbury and Pittsfield, showed substantial gains.

Past trends indicate that future expansion will occur in the southern half of the basin, where industrialization is highest. Parts of the northern portion will probably show moderate growth, particularly in the number of rural nonfarm residence.

Agriculture Agricultural land, which in both states is below the average in fertility, forms about one-fourth of the total basin area in Connecticut and less than one-tenth of that in Massachusetts. The most productive soil is found in the southern end of the basin. Dairy products exceed general crops as the principal source of farm revenue. In 1930 the Connecticut portion of the basin accounted for nearly one-third of the total state income from dairy products. Proximity to large markets favors the dairy and poultry business.

Industry The southern section is highly industrialized, especially in the Naugatuck valley, which is famed for its manufacture of brass and copper products. Waterbury and Ansonia are outstanding in this field of manufacture. Many other commodities, including machinery, fabricated metal products and

paper, are manufactured in that valley, and also in Pittsfield, an active manufacturing point at the extreme northern end of the basin. Although the major cities are the centers of industry, many manufacturing establishments are located in smaller communities along the lower reaches of the river.

A noticeable tendency is toward the movement of small industries into the industrial section of the basin from the New York Metropolitan area. The advantages of low rents, skilled labor and quick transportation are inducements for many manufacturers with headquarters in New York City to move their plants into western Connecticut. Under the influence of the business activity in the Metropolitan area, and considering its own natural advantages, a consistent growth of industry in the lower Housatonic basin may be expected.

Mining Marble and limestone deposits are found in the northern Connecticut area and in Massachusetts. Both are quarried on a limited scale.

There are, however, no prospects of increase in the production of marble or limestone products unless the fields of use of these products are extended.

Lumbering Lumber production is confined essentially to farm woodlot cuttings, which yield a minor income, as contrasted with the proportion of income they yield in the northern New England basins. Improved methods of managing farm woodlots and other privately-owned woodland seem to constitute the best means of increasing the limited lumber production of the basin. State-owned forest lands may in the future provide material assets by reason of controlled cuttings, but the principal value of such tracts lies in their use for recreation and wildlife conservation.

Recreation The Housatonic valley has natural features adapted to a variety of recreational uses. Summer residents have long favored it for their country homes, whether they be cottages, small farms or elaborate estates. The entire valley is readily accessible to large population centers. In Fairfield County, near Danbury, an artificial lake constructed primarily for water power storage is used extensively for recreation, and has the distinction of being the largest lake in Connecticut. The many ponds and streams of attractive Litchfield County provide sites for summer homes and for recreation uses. The best-known recreational resort of the region is the Berkshire Hills, which extend from Litchfield County through the entire length of Berkshire County in Massachusetts. Throughout the upper part of the basin there are numerous state forests and reservations in which recreational facilities of many types have been intensively developed, but there is apparently a need for more such areas, especially in the lower part of the basin.

Transportation The tidal portion of the Housatonic river, about 13 miles in length, has been improved by the U. S. Army Engineers to provide a channel 7 feet deep at mean low water and generally 100 feet wide to Derby and Shelton. There appears to be no necessity of improvement for navigation above this point, but it is possible that enlargement of the existing channel below Derby would be of economic advantage.

A closely woven network of highways covers practically the entire area of this valley. In general this system is adequate, except for the major east-west highways and the highway along the main river, all of which should be re-developed to meet present needs of through traffic.

Railroad service is provided to important cities and towns in the basin by lines of the N.Y., N.H. & H. Railroad. Additional service in the norther end of the valley is furnished by the Boston and Albany Railroad.

While the Housatonic Valley is crossed by the existing airways from Boston to New York and Boston to Albany, there is no scheduled air transport service from any airport in the valley at present. Existing landing fields are located in Bethany, Danbury, Torrington, Canaan, Great Barrington and Pittsfield.

WATER USE AND CONTROL

Pollution The largest towns in Massachusetts without organized sewer systems are:

	1930 pop.
Sheffield	1810
W. Stockbridge	1138
New Marlboro	921

In addition to these there are two towns which have organized water supplies, but no domestic sewage systems. Sewage is treated at Pittsfield, Lenox and Stockbridge; the remaining communities dispose of their raw sewage by dilution in the Housatonic River.

The three communities with treatment comprise about 67% of the basin population. When such a large percentage of sewage is treated, it might be expected that river conditions would be good. This would be true but for the large volumes of industrial wastes (over 8 million gallons daily) which exceed the domestic sewage flow, estimated at 100 gallons per capita, a total of about seven million gallons daily. The per capita water consumption in several towns is higher than the above assumption, but that fact is undoubtedly due to industrial use of the water.

The river water is of good quality above Hinsdale. Pollution, as indicated by biochemical oxygen demand, increases sharply from Dalton to Pittsfield, where dilution water from tributary streams has an alleviating effect. Chloride determinations indicate that this sharp rise is probably due to industrial wastes. There is another sharp rise from New Lenox to below Lee, at which point the organic pollution is at the maximum, due principally to the discharge of untreated industrial wastes. The degree of pollution decreases rapidly between Lee and Stockbridge, and from there to the state boundary there is a gradual improvement. In general the parameters of pollution, albuminoid ammonia, dissolved oxygen and oxygen consumed corroborate the B.O.D. determinations. The lowest dissolved oxygen values are in the vicinity of Pittsfield. During low flows there may be objectionable conditions elsewhere, but there are no bacterial results available for a discussion of river contamination.

There are several minor tributaries to the river, but their pollution is not serious. After the new Pittsfield sewage treatment works are completed and in operation, any further improvement in the quality of the river water will depend on industrial waste treatment, particularly at paper mills. Sewage treatment facilities for Dalton, Hinsdale, Lee, and Great Barrington are needed. If pollutive wastes are not treated, it is possible that the river may soon become useless for recreation.

In Connecticut the towns that have water supplies but no sewer systems are:

	1930 pop.	
New Milford	4700	(has some private sewers to rivers)
Bethel	4060	
Washington	1813	
Woodbury	1755	
Middlebury	1545	
Cornwall	889	
Canaan	566	

MAP Nº 8-F
KEY
8-A
8-B
8-C
8-D
8-E
8-F
8-G
Legend
SEWAGE SYSTEM-NO TREATMENT
SEWAGE SYSTEM- TREATMENT
CONSTRUCTION PROJECT
INVESTIGATION PROJECT
NOTE. POLLUTION INVESTIGATION PROJECT FOR HOUSATONIC RIVER VALLEY IN MASS.
NEW ENGLAND WATER RESOURCES
SEWAGE AND POLLUTION
HOUSATONIC - HUDSON BASINS
DEC. 1 1937
SCALE
0 0 8 16
MANCHESTER
VERMONT
BENNINGTON
POWNAL
WILLIAMS-TOWN
NO. ADAMS
ADAMS
DALTON
PITTS-FIELD
HINSDALE
LENOX
STOCK-BRIDGE
LEE
GREAT BARRINGTON
NO. CANAAN
NORFOLK
LAKEVILLE
SHARON
TORRINGTON
LITCHFIELD
KENT
THOMASTON
NEW MILFORD
WATERTOWN
SOUTH-INGTON
WATERBURY
MERIDEN
CHESHIRE
NAUGATUCK
DANBURY
BEACON-FALLS
SEYMOUR
NEW TOWN
BETHEL
HANSONA
DERBY
WALL-INGFORD
HAMDEN
RIDGEFIELD
SHELTON
NEW HAVEN
BRANFORD
TRUMBULL
BRIDGEPORT
WEST HAVEN-MILFORD
WESTPORT
FAIR-FIELD
STRATFORD
NEW CANAAN
NOR-WALK
DARIEN
STAMFORD
GREENWICH
NEW ENGLAND REGIONAL PLANNING COMMISSION
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No towns without water supplies have sewerage.

Sewage treatment is provided in 10 communities comprising 33% of the basin population. Of these ten the largest are Danbury, Torrington and Stratford. In addition to treated sewage, the streams receive large amounts of untreated sewage and industrial waste.

Throughout most of its course in Connecticut the Housatonic is a comparatively clean stream. A comparison of the averages of chemical analyses of the Housatonic River at Great Barrington, Massachusetts and Lime Rock, Connecticut show somewhat less pollution at the latter point. Stream conditions are about the same at Sandy Hook as at Lime Rock. The river is tidal below Shelton, at which point the Naugatuck joins the main river. Tidal fluctuations may cause objectionable conditions near Shelton due to the pollution from the Naugatuck River and to concentration of the raw sewage from Shelton, Derby and Ansonia, which have a total population of 41,538. The Connecticut State Water Commission has recommended the formation of a sanitary district comprising these three communities for the purpose of treatment and disposal of sewage.

Of the tributary streams the Naugatuck River, with a drainage area of 312 square miles, is the largest. It receives large volumes of raw sewage and untreated wastes, as the result of which the river is the most polluted of any in Connecticut for which analyses are given. Some samples from both the Thomaston and Beacon Falls stations, particularly those collected during dry weather flows, may be defined as weak sewage rather than polluted river water. The conditions at the former station are the better of the two and more improvement will be noted when the Torrington treatment works are in operation. Waterbury, with an estimated population of 102,000, is one of the largest inland cities in New England without sewage treatment facilities; the raw sewage discharge from this city is the chief factor of the seriously polluted conditions observed at the Beacon Falls station. The following table giving the mean runoff cfs. per square mile at Naugatuck, where the drainage area is 246 square miles, shows the gross inadequacy of dilution flow for proper disposal of the Waterbury sewage.

Year	July	August	September
1934-35	.821	.411	.654
1933-34	.541	.421	3.08
1932-33	.356	.623	1.19
1931-32	.526	.551	.478
1930-31	.607	.382	.278
Average of above	.565	.478	1.13

(Fifth and Sixth Biennial Reports, Connecticut State Water Commission.)

Theoretically, a population of 102,000 requires a dilution flow of 660 cfs. of relatively clean water; this would be 2.6 cfs. per square mile for the 246 square miles of drainage area, a flow which is seldom attained.

Analyses of the Shepaug River, which has a total drainage area of 156 square miles, show some pollution at the Roxbury station but not so much as is in the Housatonic. The flow from the west branch of the river, diverted by tunnel to reservoirs in the Naugatuck drainage area, is used for the Waterbury water

supply. There is a possibility of diversion of other headwaters for the same supply.

The Still River is a minor tributary. Although sewage treatment at Danbury, from which effluent is discharged into the river, is satisfactory, proper disposal should be made of industrial wastes, a large proportion of which comes from the hat factories.

River pollution control in the Housatonic basin is needed most in the tributary Naugatuck valley. Recommendations include a treatment plant for Waterbury and a district disposal system for Ansonia, Shelton and Derby. Partial treatment of industrial waste is desirable, but in some instances no methods of economic treatment have yet been devised.

Water Supply In the Massachusetts section of the basin there are five towns which do not have water supplies: Lanesboro (pop.1237), Richmond (pop.628), Tyringham (pop.246), Washington (pop.222) and Alford (pop.200). In the towns which are supplied, the per capita daily consumption is high, due to industrial use of water. Pittsfield, the only city, is served by a chlorinated surface supply taken from several sources.

Of the twelve towns supplied with water, two employ continuous chlorination, two have seasonal chlorination, and the others have no treatment. The majority of supplies in the basin are from surface sources.

The ground and surface waters in the basin have a low iron content. The hardest surface waters in the state are those used by Pittsfield, Monterey, Great Barrington and Lenox. One of the hardest ground waters in the state is that of Bloke's Spring in West Stockbridge.

In Connecticut there are three towns without water supplies: Oxford (pop.1177), Southbury (pop.1143) and Wolcott (pop.1035). In addition there are twelve towns of less than a thousand population which are not served. About 90% of the basin population is in towns that have water supplies. Except at Bethel, Waterbury, Watertown, and Danbury, water supply systems are in semi-public ownership. Surface supplies predominate, and practically all of these are chlorinated. There are three sand-filter plants in the basin.

The ground waters are, in general, much harder than elsewhere in New England, and in some cases the hardness is accompanied by a high total solids content. Towns served by hard ground water in whole or in part are: Salisbury, North Canaan, Sharon, Cornwall, Kent, Litchfield and Canaan. The water of the last-named supply is the hardest in the state.

Flood Control The conclusion reached by the Army Engineers in a 1932 report was that the Housatonic watershed has not, in general, been subject to frequent high runoff. An abundant ground water storage capacity, together with the large number of lakes and ponds and swamps, as well as the favorable shape of the basin have been responsible for curbing floods. The 1936 flood was the highest on record. The maximum discharge at Falls Village, Connecticut was 14,500 cfs.; at Stevenson, Connecticut the peak flow amounted to 69,500 c.f.s. The corresponding runoff per square mile for these two stations was 22.5 and 45 c.f.s. In 1927, the peak flow at these two stations was 11,700 and 33,250 c.f.s., respectively.

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The conclusion reached by the Army Engineers in their report was that a flood problem does not exist on the Housatonic River, as the annual flood damage is too small to warrant consideration of a comprehensive plan of regulation. Their finding was that such damage as has occurred has been mainly local, and that the situation can be handled locally to good advantage. Authorized by the Flood Control Act of 1936, the Army Engineers made a preliminary examination of flood control needs on the Housatonic River and are now, as a result of that examination, making a detailed study on which they will base recommendations for procedure.

Power The developed hydro-power on the main river and tributaries amounts to 122,979 horsepower. Of this amount 80,294 horsepower are developed through about 875 feet of fall on the main river, including that part called East Branch. The total fall in the main river between the crest of the dam at Hinsdale, Massachusetts and tidewater is 1422 feet, of which about 780 feet are in Massachusetts. The head developed in Massachusetts is approximately 545 feet, and in Connecticut 330 feet. The corresponding wheel installations in the two states are 9885 horsepower and 70,409 horsepower.

On the Rocky River, a small tributary of the Housatonic that has a drainage area of only 41 square miles, a pump-storage project was constructed by the Connecticut Light and Power Company as a peak load development. The project includes a reservoir with a surface area of over 8 square miles, and a usable capacity of about 135,445 acre-feet. The dam is located on Rocky River at its mouth and the power house is on the Housatonic. The reservoir is connected with the power house by open and closed conduits.

The average yearly runoff from the drainage area is but 34,435 acre-feet, about 25% of the capacity of the reservoir. The remaining capacity is filled by pumping from the Housatonic River against a head varying from 200 to 230 feet by means of an 8100-horsepower centrifugal pump located in the power house. Off-peak power is used to pump the water from the river to the reservoir. The reservoir is subsequently drawn down to carry the peak load of the power system. This plant has an installed wheel capacity of 36,100 horsepower.

The Naugatuck River, one of the principal tributaries, has a fall of about 345 feet, of which approximately 114 feet are at present developed for power. Wheel installations on this river total 2475 horsepower.

When the U. S. Army Engineers investigated the possibilities for new developments on the river they found seven sites which appeared to be economically feasible. Six of these sites are on the Housatonic River and the seventh is on Ten Mile River. The total estimated capacity of the installations is 96,915 horsepower. The table below gives the location of the sites together with certain pertinent data:

Rivers and Sites	Drainage Area Sq.-Mi.	Head-ft.	Potential Capacity 80% efficiency HP
Housatonic River			
Shelton	1575	29	17,450
Shepaug	1391	53	28,100
Stillriver	1206	44	20,250

Rivers and Sites	Drainage Area Sq.-Mi.	Head-ft.	Potential Capacity 80% efficiency HP
Boardman	1021	40	6,650
Kent Furnace	708	46	13,300
West Cornwall	685	129	8,275
Ten Mile River			
Webatuck	209	94	2,890
Total Developments			96,915

This potential power is largely controlled by power companies which have numerous hydro plants in this area, and which will probably extend their developments when the market for power is suitable. These plants could be operated as base load plants during seasons when water was plentiful and as peak load plants during dry seasons, being used to develop prime power exclusively. If they are built it will be necessary, however, to use steam reserve or other standby power to make the developments practical.

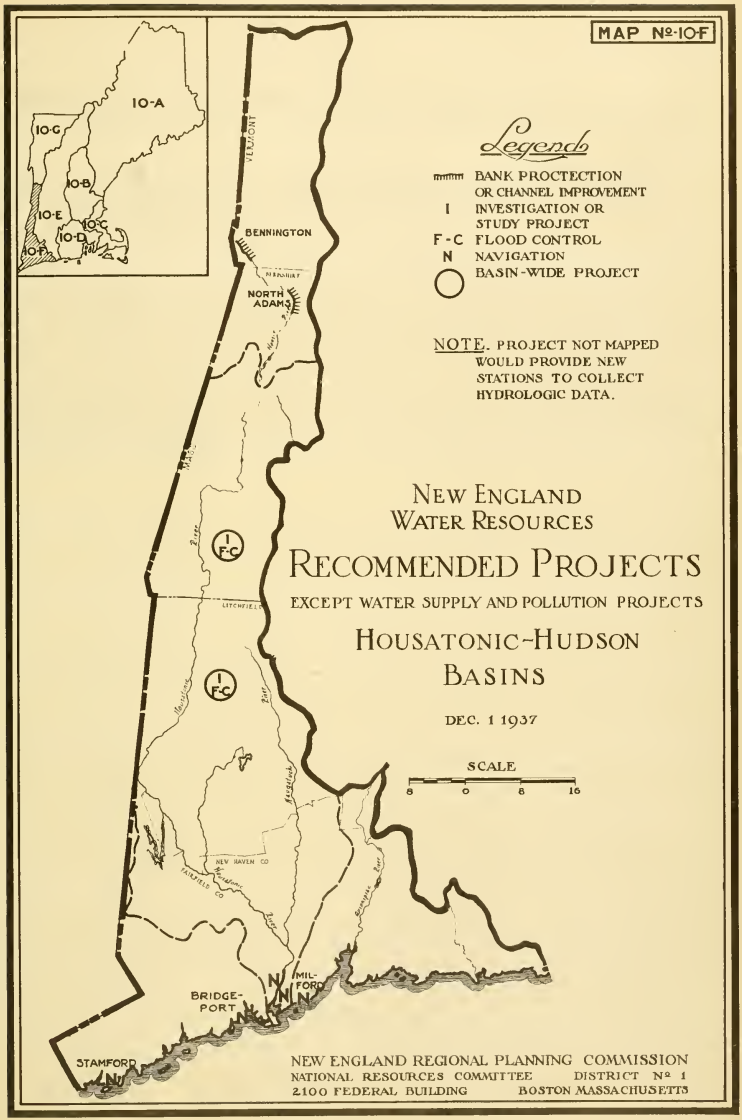
The flow of the river is very limited during the dry season of the year and it is therefore desirable to develop storage for use in increasing prime power. The investigations of the Army Engineers disclosed 3 sites which, in their opinion, would be feasible. These sites are:

Location	Drainage Area Sq.Mi.	Surface Area Acres	Storage Acre-ft.
Richmond Pond, Mass.	7.3	219	1,035
Monterey, Mass.	23.4	---	5,165
Spectacle Ponds, Conn.	1.7	275	918

In addition to these three, nearly sixty other sites were investigated for storage, but were rejected as being impracticable.

Navigation The lower reach of the stream is navigable for 13½ miles from Long Island Sound to Derby-Shelton. The controlling depth at mean low water is 7 feet. Above Shelton, a canal permits boats of less than 3-foot draft to pass a dam and proceed to Otter Rocks, 16½ miles from the river mouth. In 1936 the traffic below Shelton, amounting to 230,062 tons, consisted almost entirely of coal and petroleum products. Deepening of the channel to 18 feet in the lower five miles of the river has been authorized, contingent upon specific local cooperation.

Erosion The Army Engineers' 308 Report states that the Housatonic "is not what would be ordinarily termed a silt-bearing stream." Consequently, damages resulting from soil erosion are neither serious nor extensive. Such filling as occurs behind dams is believed to be largely an accumulation from domestic and industrial wastes. The predominant type of soil erosion recorded by the Soil Conservation Service in its reconnaissance survey is moderate sheet erosion, which occurs in a few places in the central and southern portions of the basin; the largest area is on the New York line in northwestern Connecticut. In the northern end of the basin there are some areas,


MAP Nº 10-F
10-A
10-G
10-B
10-E
10-C
10-D
10-F
Legends
BANK PROCTECTION OR CHANNEL IMPROVEMENT
I INVESTIGATION OR STUDY PROJECT
F-C FLOOD CONTROL
N NAVIGATION
BASIN-WIDE PROJECT
NOTE. PROJECT NOT MAPPED WOULD PROVIDE NEW STATIONS TO COLLECT HYDROLOGIC DATA.
VERMONT
BENNINGTON
NORTH ADAMS
MASS.
I F-C
LITCHFIELD
I F-C
NEW HAVEN CO
FAIRFIELD CO
BRIDGE-PORT
MIL-FORD
STAMFORD
SCALE
8 0 8 16
NEW ENGLAND
WATER RESOURCES
RECOMMENDED PROJECTS
EXCEPT WATER SUPPLY AND POLLUTION PROJECTS
HOUSATONIC-HUDSON
BASINS
DEC. 1 1937
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where slight sheet erosion is accompanied by occasional gullying, and there are three relatively small areas which exhibit moderate sheet erosion with occasional gullies.

Drainage Swamps in the Housatonic watershed are scattered land pockets usually at tributary headwaters. They occur most frequently in the southwestern portion of the basin around Danbury and Derby. No special drainage problems exist in this basin.

Recreation The presence of many small lakes and ponds amid the Berkshire Hills, in the northern section of the Housatonic Basin, has prompted the establishment of public recreation areas, but in the southern section of the basin, where there are fewer natural recreational assets, there is need of more play areas for the concentrated population. The rarity of water bodies raises the recreational value of all streams and emphasizes the desirability of carefully balancing the value of a stream as a means of waste disposal against its value as a potential recreation and fishing convenience. If stream environment is improved by pollution abatement, desirable game fish can be induced to repopulate the pools and eddies which are now almost abandoned.

WESTERN CONNECTICUT COASTAL BASINS

GENERAL DESCRIPTION

The Western Connecticut Coastal basins comprise that area which is drained by the streams that flow into Long Island Sound between the mouth of the Connecticut River and the Connecticut-New York State Line, except for the Housatonic River. This section of Connecticut is about 75 miles long, extends a maximum of 30 miles inland, and has a total area of 940 square miles. Although low and comparatively flat along the coast, the topography becomes rolling a short distance inland. Rock structure is predominantly sandstone and shale, broken up by intrusions of trap-rock, with some granite in the northwestern part of the basin. Soils are generally sandy, but light and fairly fertile in the lowland regions.

Over a third of the total area is in cleared farmland, and 15% is in cropland. Large sections, particularly along the Sound, may be classed as urban, while much of the inland portion is taken up by suburban estates. Approximately half of the drainage area is woodland, most of which is in scattered hardwood stands of little commercial value.

The rainfall ranges from 43 to 47 inches per year, with an average of about 45 inches well distributed throughout the year, except in July and August, when there is slightly heavier precipitation. Average temperatures are about 30° in winter and nearly 70° in summer.

The only two important streams in this coastal area are the Quinnipiac and Saugatuck rivers.

The Quinnipiac River, which rises in southwestern Hartford County and flows south about 30 miles to New Haven Harbor, drains 150 square miles of land devoted largely to industry and agriculture.

The Saugatuck River rises in central Fairfield County and flows southeast, then south about 20 miles to Long Island Sound, at Westport. It drains an area of nearly 90 square miles of suburban residential country.

The only two stations at which discharge has been recorded for more than two years are at Wallingford on the Quinnipiac River, and at Westport on the Saugatuck - where data is obtained by the U. S. Geological Survey, in cooperation with the state of Connecticut.

The figures in Table III-F are summarized from unpublished records in the office of the District Engineer (U.S.G.S.) at Hartford, Connecticut, as well as from the Survey's various Water Supply Papers covering Part I - "North Atlantic Slope Drainage Basins".

The mean annual discharge at the two gaging stations is, in cubic feet per second per square mile:

Quinnipiac River - Drainage Area 111 square miles - 1.56
Saugatuck River - " " 77.4 " " - 1.76

HUMAN OCCUPANCY

Population In 1930 this area lying between the Connecticut River and the New York state line had a population of about 660,000, and a population density of 700 per square mile, more than double that of the State of Connecticut.

There are eleven cities of more than 10,000 population:

New Haven	162,655
Bridgeport	146,716
Stamford	56,765
Meriden	38,481
Norwalk	36,019
Greenwich	33,112
West Haven	25,808
Hamden	19,020
Fairfield	17,218
Wallingford	14,278
Milford	12,660

New Haven is a busy manufacturing city and an important railroad center. Bridgeport, the leading industrial point of Connecticut, has a wide variety of manufacturing interests. Most of the cities of the basin are old established manufacturing centers, while a few, like Greenwich, are practically residential suburbs of New York City. The eleven cities listed above contain 86% of the inhabitants of the basin.

Between 1920 and 1930 the population increased in all the cities, although in New Haven the increase was negligible. It will be noted from Map 7 that very few places lost population in this ten-year period; in fact, most communities gained in each decade between 1900 and 1930. The influence of the densely populated and rapidly growing New York metropolitan region has been felt as far east as New Haven. That influence will undoubtedly continue, but it is probable that the rate of increase will be slower than in the past. It is estimated by Thompson and Whelpton that, for example, the 1930 urban population of Connecticut will increase in the next twenty-five years by about 17%, the same percentage as during the last ten-year census period. The coastal areas will probably gain more rapidly than this, but there are no indications that their development will continue at so high a rate as the 1920-1930 increase.

Agriculture The rural population is a small portion of the total, and about 90% of the rural inhabitants are classed as non-farm. The principal farming activities, which are conducted on an intensive though limited scale, are dairying, poultry raising and truck gardening, the products of which find a ready market in the nearby urban communities.

The two significant trends in rural land uses are toward increased part-time farming in small scattered plots, and displacement of full-time farming activity by residential occupancy. Both developments, results of the Metropolitan New York influence, have been intensified by the depression.

Industry By reason of its important industrial cities - Bridgeport, New Haven, Wallingford, Stamford, Norwalk and Meriden - the region ranks high in its output of manufactured products. Fairfield and New Haven counties, in which these cities lie, account for over half the value of Connecticut's manufactures. Leading products include high-grade machinery, firearms and ammunition, hardware, silverware, and clothing. Its wide diversification of manufactures and its location with respect to the New York area and the concentrated eastern markets are factors responsible for the growth of this section. Unlike other parts of New England, there is in this section a scarcity of available factory space because so many industries have recently moved here from New York and other centers.

Lumbering Woodland growth is scattered, and the productive areas are confined to farm woodlots. Even here the yield is of minor importance. Woodland is more valuable for its recreational possibilities than as a source of lumber.

Fishing Commercial fishing activities are limited to shellfishing along the coast, and even these are menaced by the polluted condition of the waters in various localities. Safeguarding and promotion of the shellfish interests require greater control over sources of pollution in both streams and coastal waters.

Recreation Along the coast the many inlets and harbors suitable for pleasure craft and the excellent bathing beaches attract summer residents. Sherwood Island State Park and Hammonasset Beach, the largest public bathing beaches in Connecticut, are so crowded as to indicate need for additional publicly-owned beaches in the region. Inland recreational facilities are not sufficient to meet the requirements of the large urban communities, but some rivers and smaller streams possess great possibilities for recreational use, and these resources should be developed. Careful planning, particularly for the protection of the waters from pollution, is essential to the proper utilization of both inland and coastal areas.

Transportation Commercial navigation is confined primarily to the ports of New Haven, Bridgeport, Stamford and Norwalk. The freight comprises imported coal and oil and raw materials, and exported products manufactured in the section.

A closely woven network of highways covers the entire basin. The Merritt Parkway, now under construction between the New York State line and the Housatonic River, is the initial example of its type of highway in New England. The Connecticut Legislature, in the 1937 Session, approved extension of this highway northeast to the Massachusetts State line.

Adequate railroad service is provided by the main line and several branches of the New York, New Haven and Hartford Railroad, which centers in New Haven.

Scheduled air transport service is furnished at the New Haven and Bridgeport airports; additional landing fields are located at Madison, West Haven, and Norwalk.

WATER USE AND CONTROL

Pollution An evaluation of the pollution problem in this area must include consideration of the large amounts of industrial waste, as well as the raw and treated domestic sewage, which are discharged into its water bodies. The deleterious effect of this pollution on the public health and economic value of the waters as recreational and shellfish areas is significant.

The larger sources of pollution are Bridgeport, New Haven, West Haven, Stamford and Milford, all of which are located on tidewater. Branford, Westport and Darien present minor pollution problems.

At New Haven, the second largest city in the state, about 40% of the sewage is treated by sedimentation, chlorination and barging of solids to sea, but more extensive works are needed to clean up the present polluted condition of New Haven Harbor. The water from the Quinnipiac River is so polluted that it aggravates rather than alleviates conditions in the Harbor. West Haven has two sewage treatment plants: one, equipped with Imhoff tanks and chlorinators, was described in the 1935 Connecticut State Department of Health Report as in poor condition; the other plant, equipped with septic tanks and chlorinators, was classified as fair. New units, which will employ chemical precipitation, chlorination and vacuum filtration, are under construction.

Sewage from Bridgeport is passed through fine screens, but this treatment is not adequate. The plan to include Bridgeport, Fairfield, Stratford and Trumbull in one Sanitary District deserves careful investigation, since Fairfield is one of the largest New England towns which has no organized sewer system; Trumbull has no sewers; and Stratford has only an inadequate Imhoff tank - chlorination plant.

Stamford has an effective Imhoff tank - chlorination plant, but it is too small to handle peak discharges. The new Milford plant is to employ the activated sludge-chlorination process; it will serve the center of the town, and should alleviate present harbor conditions.

Of the smaller communities, Westport, Branford and Darien are of sufficient size to need sewers and treatment; the two latter have no sewers and none of the three have treatment.

Of the rivers discharging into salt water, the Quinnipiac carries the most waste. Analyses at the gaging station in Wallingford, where the drainage area is 111 square miles, show the river to be heavily polluted at all times, but to greatest degree during dry weather flows. At Meriden, above Wallingford, sand filters are used, but raw sewage is bypassed during a portion of the year; according to the State Department of Health Report for 1936, settling tanks, and probably even more treatment facilities, are needed.

Southington, which is also above the sampling station, has septic tanks, sand filters and sludge beds. Wallingford has Imhoff tanks and sludge beds, but does not have equipment for treating industrial wastes from the metal works.

The extent of oil pollution in the coastal waters of the region is not definitely known, but the following quotation is significant:

> "The mortality amongst migratory wild fowl during the past year due to oil polluted water has, it is reported, been heavier than ever before, and this, notwithstanding the fact that ample Federal statutes for the control of pollution by oil with heavy fine and imprisonment attached have been in existence for many years." (6th Connecticut State Water Commission Report.)

Water Supply The communities in this area are well supplied with water; not more than half a dozen towns are without supplies. No ground water sources are listed for the area, and practically all of the surface supplies are from artificial reservoirs. A large proportion of the population is served by the New Haven Water Company and the Bridgeport Hydraulic Company. The largest publicly-owned works are at Meriden and Norwalk. Semi-public water works predominate. The runoff from about one-third of the entire basin area is used for water supplies; hence the stream flow is subject to more than the usual degree of regulation.

The New Haven Water Company, serving more people than any other water system in the state, supplies Bethany, Branford, Cheshire, East Haven, Hamden, New Haven, North Branford, North Haven, Orange, West Haven, Woodbridge, Milford and Devon. The total population of all these towns is about 255,000. The water is a chlorinated surface supply derived from several sources. Water from the Lake Whitney source is slow sand-filtered; that from the Woodbridge System, Lake Wintergreen, and Prospect Lake sources has maximum color of 40 parts per million, while the average colors are 22, 22 and 21 p.p.m., respectively. The mean value of the average color determinations for all the larger supplies in Connecticut is 14 p.p.m. Beaver Brook Reservoir, one of two emergency supplies, has an average color of 21 p.p.m.

The next largest supply in the basin, and third largest in the state, is the Bridgeport Hydraulic Company, which serves Bridgeport, Easton, Fairfield, Stratford, Trumbull, Shelton and Westport. The total population of these towns is about 209,000. Surface sources are used and in summer ammonia and chlorine are added for sterilization. Of the three sources of supply in regular use, the maximum observed colors are 50, 40, and 35 p.p.m.; the corresponding average colors are 28, 21, and 23 p.p.m. In general, the water is satisfactory, except for its high color.

The Guilford Division of the Guilford-Chester Water Company serves Clinton, East River, Guilford, Madison, Old Saybrook, Sachem's Head, Saybrook Point, and Westbrook. The supply, obtained from Kelseytown Reservoir, has an oxygen consumed value of 6.0 p.p.m., the fourth highest in the state, which value indicates the presence of much organic matter in an unstable condition.

There are five sand-filter plants in this area, - at New Haven, Meriden, Greenwich, Norwalk and Wallingford. Some sort of corrective treatment, usually chlorination, is employed at every system in these basins.

The largest supplies, those of New Haven, Bridgeport and Stamford, are certified by the U. S. Public Health Service as of satisfactory bacterial quality. It is required that the quality of water shall conform to standards set by the State Department of Health, and to insure this, all supplies are periodically examined by that Department.

Flood Control This is not, as a rule, a flood-producing region. However, in 1936 some high discharges were recorded at two points on the Quinnipiac, and at Westport on the Saugatuck. They were as follows:

River and Station	Drainage area (Sq.mi.)	Peak Flow C.F.S.	Peak Flow C.F.S. per Sq.mi.
Quinnipiac			
Wallingford, Conn.	111	1750	15.8
Southington, Conn.	17.6	568	32.2
Saugatuck			
Westport, Conn.	77.4	5310	68.8

The previous maximum discharges recorded at Wallingford and at Westport, occurring in 1934, were 1320 and 3100 cubic feet per second, respectively.

Although losses were sustained at points along these rivers in 1936, the occurrence of floods is so infrequent that flood control measures would not be warranted.

Power There is little water power developed on the streams of this area. The largest stream, the Quinnipiac River, with its drainage area of 150 square miles, has three plants with installations totaling 525 horsepower.

The total installed capacity on each of the several streams is as follows:

River	No. of plants of more than 100 HP	Total Wheel Capacity (HP)
Quinnipiac	3	525
Mill	1	250
Norwalk	2	240
Mianus	1	245
Total	7	1260

No future development on these rivers is anticipated, although redevelopment might in some cases result in improved output of the plants.

Navigation New Haven and Bridgeport Harbors, the principal ones along this coast, had in 1936 traffic amounting to 3,474,317 tons, and 1,902,351 tons, respectively. The chief commodities handled were coal and petroleum products.

Recent improvements have provided deeper and wider channels and protective works in New Haven, Bridgeport, Southport, and Five-Mile River harbors, but to maintain these channel depths requires periodic dredging at New Haven and Bridgeport. Maintenance work is needed also at Branford, Norwalk and Stamford. Bridgeport wharves are considered adequate for current traffic, but improvement of terminal and transfer equipment will be needed to accommodate the increased commerce anticipated in this growing port. Available funds will soon be expended to dredge Stamford Harbor channels.

Erosion The only type of soil erosion found in this area during the 1934 reconnaissance survey by the Soil Conservation Service was moderate sheet erosion -- erosion where 25 to 75 percent of the topsoil has been lost. The damaged section, comprising one quarter or less of the coastal drainage area between the Connecticut and Housatonic valleys, has the shape of an elongated and irregular figure seven. The bar at the top of the figure extends from the Mill River to a point east of Meriden, following, in general, the Connecticut divide; the leg follows the Pine River and then swings east of New Haven, passing through East Haven to New Haven Harbor. A second eroded area, much smaller, lies in the Wopowaug River valley in the central and northern parts of Orange.

The Connecticut coastal basins west of the Housatonic do not show conspicuously the effects of erosion.

Drainage Along the shores of Long Island Sound there are extensive marshlands, many of which are drained to permit their residential use and to reduce the malaria mosquito menace to nearby districts. Inland swamps, though numerous, are usually small, and negligible from the standpoint of drainage.

Recreation The attractive Long Island Sound shores, with inlets, harbors, and sandy beaches, have long been appropriated for seasonal recreational uses. Although there are several public beaches, they are not adequate to meet the needs of the population. The development of recreation and wildlife areas inland has been at a slower pace than along the sound. The inland streams have many desirable features, and if they could be used more the tendency of pleasure seekers to overload coastal areas would be reduced, but so long as inland streams are carriers of wastes, the full benefits of recreation and wildlife use must be foregone.

HUDSON RIVER TRIBUTARIES

GENERAL DESCRIPTION

Tributaries of the Hudson River drain portions of western Massachusetts and southwestern Vermont. The total area so drained is about 600 square miles, of which about two-thirds is in Vermont. The land is generally rugged and irregular, with high mountains on the southern and western borders. The geological structure consists of granite covered with glacial deposits of sand and gravel; there are alluvial deposits in the wider portions of the Hoosic Valley.

About 70% of the entire basin is covered with a fairly good growth of hardwoods, with some patches of evergreens. The valley lands are, in the main, devoted to farming and dairying, while many small industries are located at the falls along the main streams.

Rainfall averages about 38 inches, with half of the total precipitation coming in the five months from May through September. Temperature averages about 22° in winter and about 66° in summer.

There are three important streams in this area: the Hoosic River, its tributary, the Walloomsac River, and the Batten Kill.

The Hoosic rises in north central Berkshire County, Massachusetts and flows north, then northwest, cutting across the southwest corner of Vermont and flowing into New York State 20 miles east of its confluence with the Hudson at Mechanicville, New York. The total length of the Hoosic in New England is nearly 30 miles, and its drainage area, including that of its tributary, the Walloomsac, is 359 square miles, or about 53% of the total Hoosic basin.

The Walloomsac rises in southern Bennington County and flows west, joining the Hoosic 5 miles west of the Vermont-New York State line. The area drained by the Walloomsac is about 155 square miles, almost entirely within the state of Vermont.

The Batten Kill rises in northeastern Bennington County and flows southwest, then west across the New York State line, and thence to Schuylerville, where it flows into the Hudson. There is a total fall of only 200 feet in the 25-mile stretch of the river in Vermont, but there is a fall of over 400 feet in the 30-mile New York stretch. That part of Vermont drained by Batten Kill is 243 square miles, slightly more than half the total drainage area of the river.

Discharge records for these Hudson tributaries have been obtained by the U. S. Geological Survey in cooperation with the states of New York, Vermont, and Massachusetts at five gaging stations. Detailed data for the stations can be found in Water Supply Papers of the U. S. G. S.

The figures in Table III-F are summarized from unpublished records in the offices of the U. S. G. S. District Engineers (at Albany, N. Y. and Boston, Mass.) as well as from the Survey's Water Supply Papers covering Part I, - North Atlantic Slope Basins.

Hydrographs, denoting the monthly average runoff during the last 15 years of record, are shown on Chart 14 for the Hoosic River at Eagle Bridge, New York, and the Batten Kill at Battenville, New York.

The mean annual runoff from the Hoosic River basin, at the Eagle Bridge Station, is 1.75 cubic feet per second per square mile. This station has a drainage area of 510 square miles, and has a 24-year record.

The other stations have short periods of record, since all have been constructed within the past eight years.

HUMAN OCCUPANCY

Population The 1930 population of this basin was 62,000, of which number about 43,000 were in Massachusetts and 19,000 in Vermont. The population density was 50 per square mile in the Vermont portion, and over 200 per square mile in Massachusetts: - an average for the basin of 100 per square mile. Four-fifths of the inhabitants live in the four largest communities:

	1930 Population
North Adams, Mass.	21,621
Adams, Mass.	12,697
Bennington, Vt.	10,628
Williamstown, Mass.	3,900

North Adams, the trading center of the Massachusetts part of the basin, has many manufactories, of which the chief products are textiles; Adams and Bennington likewise have many small manufacturing establishments. Williamstown is primarily a college and residential community; Bennington is popular as the object of historic pilgrimages and as a summer resort.

As in most of the hill country in New England, the population increase in recent times has been small, less than 2% between 1920 and 1930. North Adams and Adams both lost in population because of the decline in textile manufacturing. Bennington, with more diversified manufactures than the Massachusetts cities, experienced a slight growth. Trends indicate that the future population of the basin will be the same as or slightly less than it is now.

Agriculture As the topography of the basin is for the most part mountainous and rugged, farming is confined to dairying and some general farming in the comparatively small valley areas.

Of the total farm revenue, estimated at approximately $3,500,000 in 1930, more than one-third is contributed by dairying. Farm land values in the Vermont portion of the basin are somewhat higher than in the State as a whole, probably because of the fact that summer estates artificially raise the value of land classified as agricultural.

There are no indications that farming activity will increase in the area. On the contrary, it is probable that many farms now in use will be purchased for summer estates, be placed in public ownership as parts of state or national forests, or be abandoned and allowed to revert to forest land.

Industry Most of the industrial activity is centered in the three communities of over 10,000 population. In 1933 the 6000 wage earners in these communities produced manufactured products valued at over $21,000,000. Products included wool and knit goods, wood manufactures, and fabricated metal wares. North Adams textile industries suffered severe losses during the depression, while the small establishments in Bennington, most of which utilize native raw materials, weathered the depression fairly well. The future success of industry in this area will depend largely on the extent of diversification, and more particularly on the extent to which the industries are able to utilize wood and other native materials.

Mining Marble, slate and lime have been quarried in commercial quantities in the Vermont portion of the basin. At present, however, mining operations are comparatively inactive, and will remain so until the market demand for stone products increases.

Lumbering Lumbering and lumber-using industries employ about one-fourth of the total industrial workers in the Vermont part of the basin. The 1930 lumber output included 6,000,000 board feet, as well as large quantities of cord-wood; the principal merchantable timber consists of northern hardwoods, particularly maple and birch.

Although woodlot cuttings are, and will continue to be, important supplemental sources of farm income, the future of lumbering in this basin lies in the degree to which improvements are brought about by better forest management and to which the demand for timber is increased by expansion of local wood-using industries. Such improvements will be facilitated by public ownership and management of forests, since nearly one-third of the total basin area is included in the purchase unit of the Green Mountain National Forest.

Recreation Those portions of the Hudson River Basin which lie in New England are hilly, and contain no large bodies of water; hence recreational uses do not include those dependent on water. In fact, the greater part of the recreational investments are in summer residences. The state of Massachusetts has preserved, on publicly-owned areas, the background for wilderness recreation in this region; in Vermont similar procedure has been initiated by the U. S. Forest Service. Although the population density is relatively low, excessive pollution loads are imposed upon small streams by discharge of untreated domestic and industrial refuse. In those streams where it is feasible to correct these conditions, such procedure would make possible their use for fishing, canoeing and bathing, whereas now the rivers have little recreational value.

Transportation The larger cities and towns of the basin are interconnected by a system of paved highways, but many rural sections are served only by unsurfaced roads. Plans prepared by the State Planning Boards and the New England Regional Planning Commission call for improvement, because of their significance in the regional highway system, of one north-south route passing near but not through Bennington and North Adams, and two east-west routes, one near Bennington and the other near Williamstown and North Adams.

Railroads serve all the large communities in the basin. The main line of the Boston and Maine Railroad from Boston to the west passes through North Adams. Other lines go from North Adams through Adams to Pittsfield, and from Rutland through Manchester and Bennington to Troy and New York.

There is no scheduled air transport service from any point in the basin. Landing fields at Bennington and Manchester need improvement; construction of a landing field in the North Adams-Williamstown area has been recommended by the Massachusetts State Planning Board.

WATER USE AND CONTROL

Pollution North Adams, Adams, and Williamstown, Massachusetts, and Bennington, Manchester and Pownal, Vermont, are the only places which have sewerage systems. Of these, North Adams, employing settling tanks and sludge digestion, and Manchester, employing sedimentation and aeration, are the only two which treat their sewage. The State Department of Health has recommended installation of treatment works at Adams and Williamstown in order to eliminate these sources of pollution.

Examinations of the Hoosic above and below the North Adams treatment plant show that the effluent from this plant does little to pollute the river. However, the domestic sewage discharged at Adams, Williamstown, Cheshire, Clarksburg, together with certain untreated industrial wastes discharged at North Adams, Adams and Clarksburg cause serious pollution of the Hoosic River. Analyses of biochemical oxygen demand, chloride content and total solids concentration show that this river below Adams is the most polluted stream in western Massachusetts; where the Hoosic enters the state of Vermont it is more polluted than the Housatonic where it enters Connecticut.

An indication of the amount of pollution carried by the Hoosic is the fact that it receives daily about 2 million gallons of untreated domestic wastes and 14 million gallons of industrial wastes, a total volume exceeding the minimum daily flow of the river at the Massachusetts-Vermont line. Removal of pollution from industrial wastes is necessary if the deplorable condition of the Hoosic River is to be corrected. However, treatment of these wastes, most of which are discharged by textile and paper mills, would probably necessitate financial outlays too great to be borne by the industries. Either there must be developed some less expensive type of treatment of industrial wastes than now exists, or the cost of treatment of these wastes must be defrayed, at least in part, from public funds.

There are no grave sources of pollution in the Vermont portion of the basin except at Bennington, where domestic sewage and some industrial wastes are discharged into the Walloomsac River. It is probable that sewage treatment at Bennington would result in the elimination of all serious pollution from the river.

Water Supply All the larger centers of population have organized water supply systems, most of which draw water from surface sources or springs.

In Massachusetts, towns comprising 97% of the basin population have systems. Clarksburg, with a population of 1933, is the only large town without one. The Adams and North Adams supplies are publicly owned; those of Williamstown and Cheshire are semi-public. Chlorination, seasonal in some cases, is used in all towns except Cheshire, and chemical analyses of all these supplies indicate that they are satisfactory. The Cold Spring source, which serves Williamstown, has a hardness of 128 p.p.m. Certain of the surface sources of supply for Williamstown and North Adams have watersheds which lie partly in Vermont.

In Vermont the only town without a water supply is Shaftsbury, with a population of 1631. The largest supply, that for Bennington, is taken from springs

and mountain brooks. Spring sources of supply predominate. All but the Arlington system are publicly owned. Although none are treated, the supplies appear to be of satisfactory bacterial quality with one exception: the Pownal supply is taken from a brook which shows positive B. coli tests four out of five times. This supply has a hardness of 132 p.p.m., a color of 15 p.p.m. and a chloride content which is higher than that of other surface supplies in the vicinity.

Chlorination could well be used as a precautionary measure not only at Pownal but also at other Vermont towns where the supplies have poor bacterial records.

Flood Control. The maximum flood of record on the Hoosic River occurred in November, 1927, when the peak discharge at Eagle Bridge, New York, amounted to 29,800 cubic feet per second, or 58.3 cubic feet per second per square mile. Flood damage cuased heavy losses in the cities within the valley. The flood in March, 1936, with a peak discharge of 23,500 cubic feet per second, caused less damage.

The report of the U. S. Army Engineers, contained in House Document 684, 71st Congress, 3rd Session, listed 11 sites which were studied and found to be suitable locations for detention basins. Were this system of basins placed in operation, the estimated peak discharge for a standard flood at Eagle Bridge would be reduced from 76,100 cubic feet per second, to 6100 cubic feet per second, or well within the channel capacity at that point. However, the report indicated that the cost of such a system would be greatly in excess of the benefits received.

The Engineers concluded that a reasonable degree of protection from ordinary floods could be obtained by local channel improvements. North Adams, Massachusetts, would be benefited by the clearing of the channel and the construction of drift barriers in the river above that city. Such a project has already been authorized by Congress. To reduce flood damages on the Walloomsac at Bennington, Congress has authorized bank revetment and channel improvement, to cost approximately $216,000.

The Batten Kill valley experienced serious floods in 1904, 1913, 1927 and 1936. The peak discharges at Battenville, New York, for those floods were, respectively, 11,700, 8400, 21,300, and 14,400 c.f.s.

The estimated loss in 1927 was $300,000, most of which was sustained by railroads and highways. In 1936, the estimated flood damage amounted to somewhat less.

Investigations made by the U. S. Army Engineers and reported in House Document 685, 71st Congress, 3rd Session, revealed possibilities for six sites for detention basins, four of which were in Vermont and two in New York. The Vermont sites were as follows:

River	Location	Capacity (acre-feet)	Estimated Cost
Green	W. Arlington	6,640	$966,000
Warm Brook	E. Arlington	10,100	552,000
Roaring Branch	Chiselville	4,700	360,000
Batten Kill	Sunderland	18,300	684,000

The cost of these reservoirs, together with the cost of the New York State reservoirs, was too great, in contrast to average annual loss, to merit their construction. If a flood control plan were to be worked out, it is probable that the two New York State reservoirs alone would show the greatest benefit and the best economy. It was estimated that the Shushan reservoir would have allowed the discharge below the site to have remained in the river channel in the 1927 flood.

The reservoirs recommended by the Vermont Flood Control Committee, spoken of under "Power", would offer a certain amount of flood benefit. However, it cannot be shown that the flood benefits of any combinations of reservoirs in this valley will approach the flood losses near enough to bring them within economical limits.

Power Existing hydro plants of more than 100 h.p. capacity in Massachusetts and Vermont on the Hudson River tributaries have wheel installations totalling 4250 horsepower. This power is divided between 2330 horsepower in Massachusetts and 1920 horsepower in Vermont. All plant capacities are under 1000 horsepower, the largest being at North Pownal, Vermont, on the Hoosic River, where the wheel installation is 800 horsepower. Only one plant, that of the Twin State Gas and Electric Company on the Walloomsac River at Bennington, Vermont, is a public utility. This plant has an installed capacity of 290 horsepower developed under a 43' head.

The following list shows the location of these power plants by streams and states (not including New York State installations):

River	State	No. of Plants	Total Wheel Capacity H. P.
Hoosic	Massachusetts	3	1020
Hoosic	Vermont	1	800
So. Branch, Hoosic	Massachusetts	6	590
No. Branch, Hoosic	Massachusetts	4	720
Walloomsac	Vermont	5	890
Paran Creek	Vermont	1	100
Batten Kill	Vermont	1	130

There are five plants on the lower 25 miles of the Hoosic River, in New York State. These plants have a total installed capacity of 26,030 h.p. The largest is the Schaghticoke plant of the New York Power and Light Corporation, where 17,900 h.p. are developed under an average head of about 152 feet. Another plant belonging to the same utility company, located at Johnsonville, develops 5360 h.p., while a third, that of the Twin State Gas and Electric Company at Hoosic Falls, develops 1570 horsepower.

The storage on the Hoosic River is small - 7600 acre-feet above the plant at Schaghticoke, New York. In House Document #684, 71st Congress, Third Session, the U. S. Army Engineers propose a comprehensive development of the water power resources of the Hoosic to include the construction of five reservoirs and power plants and the expansion and rehabilitation of ten of the existing plants. The estimated cost of the plan is $11,871,000 - $5,814,000 for reservoirs and $6,057,000 for plants. The total wheel installation would be nearly 60,000 horsepower; the total reservoir capacity would be 141,000 acre-feet, to be used for regulation of the flow of the river.

Two of the five reservoirs would be located in Massachusetts; the remainder in New York State. The location of these reservoir sites, together with pertinent data, is given below:

River and location	Drainage Area (sq.mi.)	Water Surface (Acres)	Storage below spillway level (acre-feet)
North Branch above No. Adams	34.0	940	28,280
Green River below Williamstown	32.4	880	35,760

Two of the five new power developments would be located in Massachusetts, the remaining three in New York State. One site is on Green River below South Williamstown, Massachusetts, where 320 feet of head would be utilized to develop 2600 horsepower and to produce an annual output of 8,600,000 kwh. The second plant in Massachusetts is on the North Branch, above North Adams, where 395 feet of head would be utilized to develop 3300 horsepower and to produce 11,100,000 kwh. annually.

The Army Engineers conclude that the plan presented would be feasible for gradual development as the market for new power increases.

In 1930, an investigation of reservoir and power sites on the Walloomsac River was made for the Vermont Advisory Committee of Engineers on Flood Control, and one storage and power project, located at Bennington, Vermont, was recommended for future development. The main dam site is on Jewett Brook at its junction with South Stream. A dam on Walloomsac Brook would divert its flow into the reservoir. The reservoir would control about 68 square miles of drainage area and would have about 15,000 acre-feet of storage. This storage could be used to increase the lower water flow by 59 cubic feet per second, which would give a low water flow of 73 cubic feet per second at Bennington, 78 at Paper Mill Village, and 85 at North Hoosic.

A head of 151 feet could be developed at the reservoir site, and wheel installations of 3000 horsepower would produce an annual output of 11,000,000 kilowatt hours, over half of which would be primary power.

In addition to the 151 feet of head at the site, 72 feet would be available at five existing developments below Bennington. A total wheel capacity of 5500 horsepower, including the Bennington installation, would be warranted. The total annual output would be 20,000,000 kilowatt-hours, of which 9,000,000, or about 45%, would be primary power.

The water would be used still further through 199 feet of head on the Hoosic River. The unit cost of the total storage was estimated to be $4.79 per million cubic feet per foot of head, while the estimated cost of the power development at the reservoir site was $386,000, or $129 per horsepower. Considering the storage and power together, the total cost was estimated to be $2,019,000 - $364 per horsepower of the 5500 horsepower delivered, or 1.07¢ per kilowatt-hour.

This cost was considered high but, in view of the value of the reservoir for flood control and of the possibility of prorating the cost among the plants on the Hoosic River below, as well as on the Walloomsac River below Bennington, so that the annual cost per kilowatt-hour at the several plants on the respective rivers would be about 0.93¢ and .75¢, the conclusion was reached that the project was worthy of consideration.

Two reservoir sites on the Batten Kill were investigated in 1930 by the Advisory Committee of Engineers on Flood Control for Vermont. The first was at Sunderland, Vermont, on the Batten Kill, and the second was on Warm Brook near Arlington, Vermont. The Sunderland site had a capacity below spillway level of about 21,000 acre-feet, the Warm Brook site about 11,000 acre-feet. The storage in these reservoirs would increase the low water flow by a total of 63 cubic feet per second -- 42 cubic feet per second for the Sunderland and 21 cubic feet per second for the Warm Brook Reservoir. The estimated costs were, respectively, $1,468,000 and $1,117,000.

A power development at Sunderland to develop 650 horsepower under 31 ft. head, with an annual output of 2,100,000 kwh, was estimated to cost $39,000. Another development near Arlington, on Warm Brook, would utilize about 162 feet of head and develop 1200 horsepower, producing 4,300,000 kilowatt-hours annually. The cost of this development was estimated to be $136,000.

In their report the engineers concluded that the cost of these sites would be such as to preclude further consideration.

The investigations of the U. S. Army Engineers, as discussed in House Document #685, 71st Congress, 3rd Session, showed no economical storage or power development possibilities in Vermont. A proposed reservoir above East Salem, New York, would flow back to the Vermont-New York state line, but would benefit plants in New York State only.

Erosion The Massachusetts portion of the Hoosic River basin has suffered from soil erosion over approximately half its area. The sloping topography has led to gullying of large areas near Adams and along the Green River. Except in two small areas, moderate sheet erosion has already been accompanied by gullying.

The Vermont part of the Hudson basin has three large eroded sections. Along the Batten Kill from Shaftsbury to Manchester, there is slight sheet erosion with occasional gullying. North of Manchester an area of several square miles evidences moderate sheet erosion marked by occasional gullies. The third area, south of Bennington, is also subject to moderate sheet erosion and gullying. Unless improved land management and forestry practice are put into effect, large areas will be destroyed by erosion.

Drainage The Hudson tributaries within New England lie in hilly or mountainous terrain where swamp lands rarely occur. Consequently the need for drainage in this region is negligible.

Recreation The high degree of pollution in the main rivers of this area creates a serious recreation problem, primarily because there is so little other water available for recreational use. Even though swimming is unsafe throughout much of the Hoosic, nevertheless that river is frequently used for this purpose. If it is economically feasible, pollution should be eliminated from the Hoosic and Walloomsac rivers. If it is not, then certainly artificial water bodies should be developed to meet the demand for safe bathing.

Much of this area is still in a semi-wilderness state; hence it offers an ideal environment for wildlife. State protection functions as an additional

factor in the maintenance of a stable wildlife population. Purification of streams would help to restore the depleted supply of game fish.

National and State forests not only conserve the runoff from large headwater areas but also constitute ideal settings for many types of wilderness recreation in summer and winter.

TABLE III-F

SUMMARY OF STREAM FLOW RECORDS - HOUSATONIC-HUDSON BASINS

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
Housatonic River Basin						
Housatonic R. near Gt. Barrington, Mass.	280	23	8,740	0	525	8,990
at Falls Village, Conn.	644	24	14,200	24	1,028	14,500
at Stevenson, Conn.	1550	8	48,600	0	2,190	69,500
Ten Mile River near Gaylordsville, Conn.	204	7	8,620	14	247	10,200
Still River near Lanesville, Conn.	70.4	5	1,710	10	95.6	2,080
Shepaug River near Roxbury, Conn.	133	6	5,400	6.8	215	7,000
Pomperaug River at Southbury, Conn.	75.8	4	4,030	5.2	125	6,600
Naugatuck River near Thomaston, Conn.	73.0	6	4,300	11	154	5,950
near Naugatuck, Conn.	247	14	--	29	401	18,300
Leadmine Brook near Thomaston, Conn.	24.1	6	1,560	0.5	41.7	2,470
Coastal Basins						
Quinnipiac River						
at Wallingford, Conn.	111	6	1,620	9	173	1,750
at Southington, Conn.	17.6	1	516	3.2	25.9	568
Eight-Mile River at Plantsville, Conn.	15.8	1	524	5	24.4	755
Saugatuck River near Westport, Conn.	77.4	4	4,020	1.3	137	5,310
Hudson River Basin						
Batten Kill						
at Arlington, Vt.	151	8	7,520	43	323	11,100
at Battenville, N.Y.	394	14	18,000	77	718	21,300

SUMMARY OF STREAM FLOW RECORDS - HOUSATONIC-HUDSON BASINS

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
Hudson River Basin (cont.)						
Hoosic River						
at Adams, Mass	46.3	5	2,410	12	90.7	3,670
at Eagle Bridge, N. Y.	510	24	26,000	24	894	29,800
North Branch - Hoosic R.						
at North Adams, Mass.	39	5	3,800	3.8	92	9,980
Walloomsac River						
near No. Bennington, Vt.	111	5	4,660	4	219	6,600

TABLE IV

EXPLANATORY NOTES
Concerning the table of
SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

Column 1. Town or City. Municipalities, arranged alphabetically, where available information positively indicated the existence of an organized sewerage system.
Column 2. Population 1930. Entire population of the civil division as reported by the 1930 Census.
Column 3. Population Served. Best available estimate of the persons served by an organized system.
Column 4. Discharge in thousand gallons per day. The best available estimate of the volume of sewage discharged.
Column 5. Treatment. Abbreviations, noted below, indicate the type of treatment applied to the domestic wastes.
Column 6. Chief sources of Industrial Wastes. The industries which commonly pollute streams are indicated by concise reference to the type of plant, product or raw material.

Symbols

--	No information available
(P)	Partial
(s)	Summer resort
(S)	State institution
(U)	College or University
Various	Several industries present with none clearly predominant.
Milk	Refers to pasteurizing, ice cream and dairy plants.
Fert.	Fertilizer factory
Oil	Petroleum products; storage or distribution plants.
Gas	Illuminating gas manufacturing plant.
Cannery	Includes fish packing.

Im.	Imhoff Tank	A.	Aeration
Sp.	Septic Tank	Cl.	Chlorination
SF.	Sand filtration	St.	Settling
F.	Filtration	Sc.	Screening (fine)
CP.	Cesspool	Br.	Barging sludge to sea
Sl.	Sludge treatment	Sm.	Sedimentation
AcSl.	Activated sludge plant	Ir.	Irrigation

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments

TABLE IV-F

SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

HOUSATONIC RIVER

Town or City	Domestic Sewage: Pop. 1930	No. of Services	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Dalton, Mass.	4,220	--	1,210	none	Paper
Great Barrington	5,934	--	--	none	Textiles & paper
Hinsdale	1,144	--	--	none	--
Lee	4,061	--	--	none	Paper
Lenox	2,742	--	300	Sm.SF.	Paper
Pittsfield	49,677	6,892	5,600	Sm.SF.(P)	Various
Stockbridge	1,762	--	240	SF.(80%)	--
		Served			
Ansonia, Conn.	19,898	19,000	3,620	none	Brass and copper
Beacon Falls	1,693	1,000	100	none	--
Danbury	26,955	19,000	4,500	Sm.Sl.SF.	Hats and gas
Derby	10,788	10,000	1,300	none	--
Kent	1,054	100	10	none	--
Litchfield	3,574	1,000	250	SF.Cl.	Laundry
Naugatuck	14,315	13,500	1,750	none	Candy
New Milford	4,700	2,000	200	none	Cotton
Newtown	2,635	1,100	150	Im.Sl.SF.	--
Norfolk	1,298	1,200	300	Sp.SF.Sl.	--
North Canaan	2,287	750	50	Sp.	--
Salisbury	2,767	700	100	Sp.Im.Sl.SF.	--
Seymour	6,890	3,000	500	none	Paper and wire
Sharon	1,710	200	20	Sp.F.	--
Shelton	10,113	9,500	1,425	Im.Sl.Cl.5%	Wire and gas
Thomaston	4,188	1,000	100	none	Clocks
Torrington	26,040	24,000	6,500	none (1)	Various
Waterbury	99,902	70,000	12,000	none	Gas & metal goods
Watertown	8,192	2,000	300	Im.Sl.F.Sm.	Silk and rayon

(1) Treatment plant under construction; Sm.Sl.

WESTERN CONNECTICUT COASTAL

Bridgeport, Conn.	146,716	147,000	20,000	Sc.(P)	Various
Cheshire	3,263	450	30	SF.	--
Greenwich	33,112	28,250	2,194	Im.75%;St.25%; Sl.Cl.100%	--
Hamden	19,020	11,700	400	Sm.Br.Cl.	--
Meriden	38,481	28,000	2,800	SF.	White metal goods
Milford	12,660	(1)	--	(1)	Laundry
New Canaan	5,456	1,575	300	Sl.SF.Cl.	--
New Haven	162,655	162,000	20,000	Sm.Br.Cl. 43%	Various

WESTERN CONNECTICUT COASTAL (continued)

Town or City	Domestic Sewage: Pop. 1930	Served	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Norwalk, Conn.	36,019	20,500	5,000	Sc.Sm.Sl.Cl.	Cloth goods
Ridgefield	3,580	1,600	200	Sp.Sl.SF.	--
Southington	9,237	6,000	1,000	Sp.Sl.SF.	Hardware
Stamford	56,765	40,000	4,500	Im.Sl.Cl. 75%	Gas
Stratford	19,212	10,500	1,000	Im.Sl.Cl.	Brake lining
Wallingford	14,278	13,000	1,500	Im.Sl.	--
West Haven	25,808	23,000	1,650	Im.Sl.Cl.(2)	Velvet
Westport	6,073	1,500	150	none	Fibre board and liquor

(1) New sewer system and treatment plant under construction; Sm.AcSl.Sl.Cl.
(2) New plant under construction; Sm.St.F.Cl.

HUDSON RIVER

		Services			
Adams, Mass.	12,697	--	1,300	none	Textiles & paper
North Adams	21,621	--	2,925	Sm.Sl.	Textiles
Williamstown	3,900	--	400	none	--
		Served			
Bennington, Vermont	10,628	9,350	--	none	Woolens, paper & clothing
Manchester	2,004	200	--	Sm.A.(P)	Milk
Pownal	1,425	20	--	none	Tannery

EXPLANATORY NOTES
concerning tables of the
ORGANIZED WATER SUPPLY SYSTEMS

Column 1. Town or city. Municipalities, arranged alphabetically, where available information indicates the existence of an organized public or semi-public water supply system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 census.

Column 3. Population Served. Best available estimate of the persons served by an organized system (as for the year 1936).

Column 4. Consumption in thousand gallons per day. Best available estimate of the normal daily requirement.

Column 5. Sources of supply. The type of source drawn from is indicated by symbols:- R. for Reservoir, Pond or Lake; W. for Wells, either deep or shallow; Spr. for Spring; Str. for Streams.

Column 6. Watershed area in square miles. Best available estimate of the drainage area upon which the water supply is dependent.

Column 7. Capacity in millions of gallons. Best available estimate of the quantity of water stored by, or immediately available to, the municipal supply.

Column 8. Type of Treatment. Available information concerning the methods used to improve the quality of the water served.

SYMBOLS

(2), etc. Numerals enclosed in parentheses indicate the number of separate water supply systems which serve the municipality. Where there is only one system no symbol is necessary.

(S) Includes State institution
(T) Includes Summer population served
(U) Includes College or School
(s) Provides Summer service only
(a), (b), etc. Letters enclosed in parentheses link civil divisions served by the same water source:-
In column 3 and 4 they link municipalities where available information does not give the number served in each town.
In column 5 letter indicates that the civil division imports water.
In column 6 and 7 letter indicates that the civil division exports water.
Letters link municipalities within one state and basin; cross-references between basins or states appear in footnotes.

Symbols (continued)

A.	Aeration	K.	Activated carbon
Al.	Alum	L.	Lime
AlSl.	Aluminum sulphate	MF.	Mechanical filter
Am.	Ammonia	PF.	Pressure filter
AmSl.	Ammonium sulphate	pH.	Correction of reaction
AS.	Alum - Soda Ash	RF.	Rapid filter
CC.	Corrosive correction	S.	Soda ash
Cl.	Chlorine	SF.	Slow filter
Co.	Coagulation	Sm.	Sedimentation
CuSl.	Copper sulphite	SoCl.	Sodium hypochlorite
F.	Filter	St.	Storage of protective significance.
IR.	Iron removal		

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments
Annual Reports, Public Utilities Commissions

TABLE V-F

ORGANIZED WATER SUPPLY SYSTEMS

HOUSATONIC BASIN

Town or City	Pop. 1930	No. of Services	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal	Type of treatment
Dalton, Mass.	4,220	1,109	1,211	R.	22.5	229.8	none
Egremont	513	98	--	R.	2.5	.050	Cl.
Great Barrington(2)	5,934	1,836	--	R.	1.4	240	none
Hinsdale	1,144	--	--	R.	--	--	none
Lee	4,061	880	--	R.	10.7	74.09	Cl.
Lenox	2,742	354	300	R.	.7	65.3	Cl.
Monterey	321	34	--	R.	.2	.02	none
New Marlborough(3)	864	--	--	Spr.	--	--	--
Pittsfield (2)	49,677	8,911	5,605	R.	20.6	5785	Cl.
Sheffield	1,650	136	--	Spr.	--	--	none
Stockbridge (2)	1,762	496	240	R. & Spr.	2.5	250	Cl.
West Stockbridge	1,124	76	--	Spr. & R.	--	.005	--
		Served					
Ansonia, Conn.	19,898	18,000	1,510	R. & Str.	3.9(a)	611(a)	Cl.
Beacon Falls	1,693	1,000	94	(b)	--	--	Cl.
Bethel	3,886	3,200	300	R.	.7	195	A.Co.Sm.RF.Cl. 30%;SF.70%
Canaan (s) (2)	565	400	24	Str. & W.	--	--	none
Cornwall	878	170	10	Str. & Spr.	--	--	none
Danbury	26,955	27,000	4,000	R.	9.7	3034	A.Co.Sm.RF.80%; Cl.95%
Derby (2)	10,788	10,500	901	R. & (a-1%)	3. (d)	119 (d)	Cl.
Kent	1,054	400	24	Str.Spr.&W.	.1	3	none
Litchfield	3,574	1,000	60	R.	.6	10	PF.
Middlebury (3)	1,449	650	36	W.Spr. &(c-25%)	--	--	Cl.
Naugatuck	14,315	14,000	2,360	R.	5.2	637	Cl.
New Milford	4,700	3,000	180	R.	1.4	86	none
Newtown(2)	2,635	1,050	61	R. & Spr.	1.1	136	Cl. 59%
Norfolk	1,298	1,200	72	R.	1.7	200	none

Town or City	Pop. 1930	Served	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal	Type of treatment
North Canaan, Conn.	2,287	850	51	R. & W.	.2	3	none
Salisbury	2,767	2,000	120	R.	1.2	21	none
Seymour (3)	6,890	6,250	586	R.(a-2%;d-1%)	1. (b)	146 (b)	Cl.
Sharon	1,710	800	48	R.	2.6	41.6	Cl. 96%
Shelton	10,113	9,000	1,250	R.	15.1(e)	2762 (e)	Am. Cl.
Stratford (A)	19,212	6,500	650	(e)	—	—	Am. Cl.
Thomaston	4,188	1,500	187	R.	.7	120	A.Co.Sm.RF.
Torrington	26,040	23,500	2,500	R.	10.3	2077	Cl.
Washington (2)	1,775	300	18	Spr. & W.	—	—	none
Waterbury	99,902	100,000	7,680	R.	56.2(c)	3445 (c)	Cl.
Watertown (2)	8,192	4,000	310.9	W.	—	—	Cl.12%;SA.88%
Woodbury	1,744	700	42	R.	1.5	12	none
Plymouth	(see Connecticut River Basin)			Exported R. & W.	.1	19	none

(A) see Stratford, Western Connecticut Basin

WESTERN CONNECTICUT COASTAL BASIN

Branford, Conn.	7,022	7,000	500	(c)	—	—	Cl.
Bridgeport	146,716	147,000	20,000	R.	39.6(b)	9664(b)	Am.Cl.
Cheshire (2)	3,263	1,930	136	(c-95%; d-5%)	—	—	Cl.
Clinton	1,574	1,200	96	(e)	—	—	Cl.
Darien (2)	6,951	5,400	404½	(a)	—	—	Am.Cl.
Easton	1,013	150	10	(b)	—	—	Am.Cl.
East Haven	7,815	8,900	720	(c)	—	—	Cl.
Fairfield	17,218	18,000	1,650	(b)	—	—	Am.Cl.
Greenwich	33,112	33,520	3,061	R.	10.6	1236	A.Co.Sm.RF.Am.Cl.
Guilford	3,117	2,300	184	R.	10.(e)	119(e)	Cl.
Hamden	19,020	21,000	1,900	(c)	—	—	Cl.
Madison	1,918	1,400	112	(e)	—	—	Cl.
Meriden	38,481	32,800	2,570	R.	5.	1000	A.Co.Sm.RF.Cl.
Milford	12,660	12,500	970	R. & (c)	1.3	17	Cl.

WESTERN CONNECTICUT COASTAL BASINS (continued)

Town or City	Pop. 1930	Served	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal	Type of treatment
New Canaan, Conn.	5,456	4,000	565	R.	1.3	77	Co.PF.Cl.
New Haven	162,655	162,600	19,550	R.	90.3(c)	10065(c)	SF25%;Cl.100%
North Branford	1,329	130	10	(c)	—	—	Cl.
North Haven	3,730	3,200	250	(c)	—	—	Cl.
Norwalk (2)	36,019	34,000	5,300	R.	19.8	1065	Cl.L.RF.54%;A.SF.L. 46%
Old Saybrook(s)(3) (A)	1,643	2,015	139	W. & (e-69%)	—	—	Cl.69%
Orange	1,530	200	12	(c)	—	—	Cl.
Plainville (2)(B)	6,301	2,560	93	R.W.& New Britain-54%	.4	160	Cl.54%
Ridgefield	3,580	2,100	200	R.	.3	500	SA.Cl.
Southington	9,237	8,520	726	R.	1.8	156	Cl.
Stamford (3)	56,765	45,500	4,302	R.	21.7(a)	3270(a)	Am.Cl.
Stratford (C)	19,212	13,000	1,300	(b)	—	—	Am.Cl.
Trumbull	3,624	800	60	(b)	—	—	Am.Cl.
Wallingford (2)	14,278	13,800	1,172	R.	10.1	694.2	A.Co.Sm.RF.1%; Cl.100%
Westbrook	1,037	700	56	(e)	—	—	Cl.
Weston (s)	670	150	7	Str.	.1	—	Cl.
Westport	6,073	6,000	480	(b)	—	—	Am.Cl.
West Haven	25,808	28,500	2,850	(c)	—	—	Cl.
Woodbridge	1,630	400	30	(c)	—	—	Cl.
				Exported			
New London	(see Thames Basin)			R.	7.2	1054	Cl.

(A) see Old Saybrook, Connecticut Basin
(B) see Plainville, Connecticut Basin
(C) see Stratford, Housatonic Basin

HUDSON RIVER BASIN

Town or City	Pop. 1930	No. of Services	Consumption thous. gal/day	Sources of supply	Watershed area sq. mi.	Capacity mil/gal	Type of treatment
Adams, Mass.	12,697	2,290	--	R. & W.	10.4	4.5	Cl. 50%
Cheshire	1,697	195	--	R.	4.1	.08	none
North Adams	21,621	3,394	2,924	R. & W.	12	295.5	Cl. (P)
Williamstown	3,900	652	--	R. Spr. & Str.	.8	11.9	Cl. (P)
		Served					
Arlington, Vt.	1,441	1,100	90	Spr.	--	--	none
Bennington (2)	10,628	9,700	1,150	Spr., R. & Str.	--	137.5	none
Dorset (2)	1,120	300	19	Spr.	--	.1	none
Manchester	2,004	1,500	112	Spr.	--	2.5	none
Pownal (2)	1,425	720	45	Str. & Spr.	.08	2.1	none

TABLE VI-F

EXISTING WATER POWER - HOUSATONIC - HUDSON BASINS

RIVER	NO. OF PLANTS IN		CAPACITY OF PLANTS OF			CAPACITY USED FOR		TOTAL CAPACITY
	Ms.	Ct.	over 10,000 HP.	1,000 to 9,990 HP.	under 1,000 HP.	Utility	Mfg.	Horse-power
HOUSATONIC	26	22	102,500	6,834	13,645	107,768	15,211	122,979
Main Stream	10	8	66,400	6,834	4,610	69,148	8,696	77,844
East Branch	8	0	0	0	2,450	120	2,330	2,450
Middle Branch	5	0	0	0	780	0	780	780
Naugatuck	0	6	0	0	2,475	0	2,475	2,475
Others	3	8	36,100	0	3,330	38,500	930	39,430
HUDSON TRIBUTARIES	Ms. 13	Vt. 8	0	0	4,250	290	3,960	4,250
Hoosic	13	1	0	0	3,130	0	3,130	3,130
Walloomsac	0	6	0	0	990	290	700	990
Batten Kill (Others)	0	1	0	0	130	0	130	130
WESTERN CONN. COASTALS		Ct. 7	0	0	1,260	475	785	1,260
Quinnipiac		4	0	0	775	475	300	775
Others		3	0	0	485	0	485	485
	PLANTS							
GRAND TOTAL HOUSATONIC, HUDSON AND W. CONN. COASTALS		76	102,500	6,834	19,155	108,533	19,956	128,489

TABLE VII-F: EXISTING STORAGE

HOUSATONIC-HUDSON BASINS

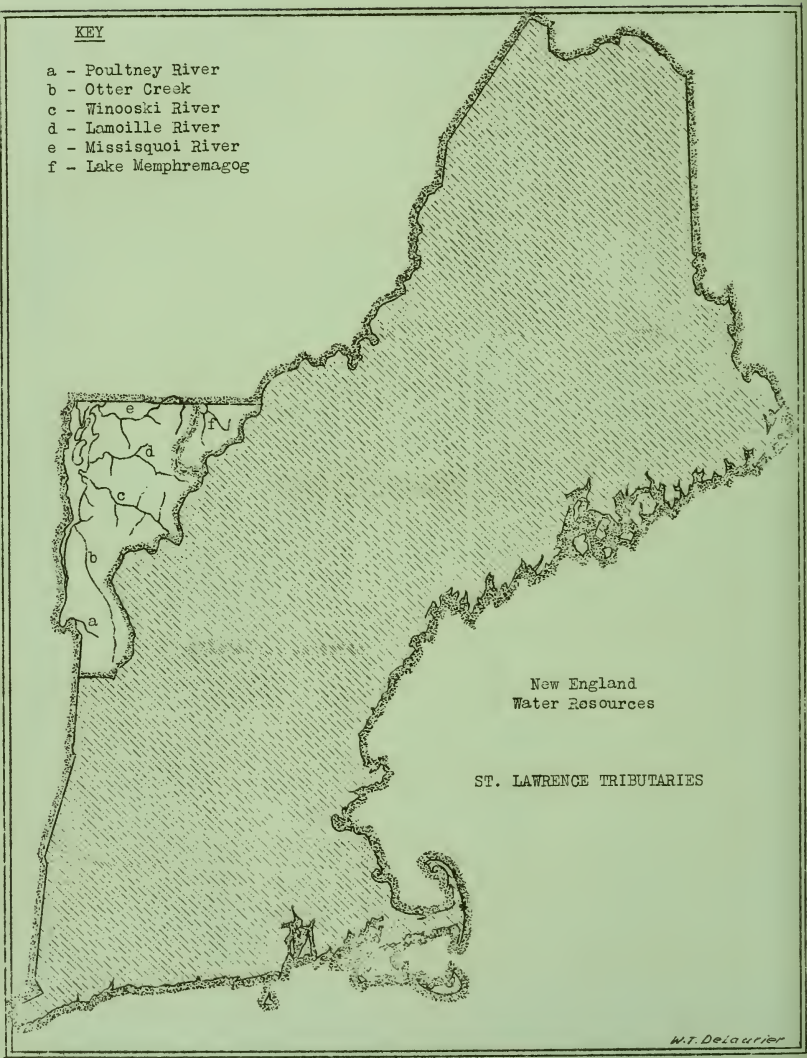
	Drainage Area Sq.Mi.	Water Surface Sq.Mi.	Storage Capacity Acre-feet	Storage Equivalent Inches of Runoff
Housatonic Basin				
Lake Candlewood	41	8.3	135,445	62.*
Additional Storage, Conn.			6,300	
" " , Mass.	____		15,600	____
Estimated Total	1,950		160,000	1.5

* Water pumped from Housatonic River into Reservoir for power purposes.

HUDSON TRIBUTARIES

Roosic Basin				
Clarksburg Reservoir (No.Br.)	34	0.1	250	0.1
Cheshire Reservoir (So.Br.)	30	0.6	1,540	1.0
Estimated Total	204		2,000	0.2

ST. LAWRENCE TRIBUTARIES


KEY
a - Poultney River
b - Otter Creek
c - Winooski River
d - Lamoille River
e - Missisquoi River
f - Lake Memphremagog
a
b
c
d
e
f
New England
Water Resources
ST. LAWRENCE TRIBUTARIES
W.T. Delaurier

ST. LAWRENCE TRIBUTARIES

GENERAL DESCRIPTION

The New England portion of the St. Lawrence basin comprises that part of Vermont which is drained by the Richelieu and the St. Francis rivers. The principal sources of these two tributaries to the St. Lawrence are Lakes Champlain and Memphremagog, respectively.

Lake Memphremagog, an international lake about 25 miles long and 3 miles wide, drains 450 square miles of the most highly developed grazing country in New England. East of this area are about 125 square miles of comparative wilderness drained by small streams which flow into the St. Francis River system below the outlet, in Canada, of Lake Memphremagog.

An area of about 4300 square miles, all that part of Vermont west of the Memphremagog and Connecticut River basins and north of the Hudson River basin, is drained by Lake Champlain, which empties into the Richelieu River just north of the International boundary. The Lake and its tributary, the Poultney River, form the New York-Vermont boundary for a distance of 120 miles. The eastern watershed of the Champlain basin is, in general, well-defined, high, and irregular. In the northern part of the basin, however, two rivers, the Winooski and the Lamoille, have broken through the main ridge of the Green Mountains. The divide between these rivers and the Connecticut is less well-defined than are other parts of the Champlain watershed.

The western slope of the Green Mountains has a rather rapid drop to fairly low, rolling country -- the excellent agricultural region known as the Champlain Valley. The predominating rock of the Green Mountain Ridge is granite. To the west of this ridge are large quantities of calcareous rock, especially marble; and in the lowlands there are deposits of sandstone, limestone, slate, and schist. Soils are principally gravel and till in the higher portions of the basin, but much of the fertile valley land is clayey loam over thick, poorly-drained deposits of heavy clay.

With the possible exception of the Maine potato region, the Champlain Valley is the most intensively cultivated part of New England. Most of the crop land is in the comparatively level main valley, while much of the cleared pasture is on the steep slopes of the tributary streams. The crest of the Green Mountains is completely forested with mixed conifers and hardwoods, and throughout the valleys there are small scattered stands of second-growth timber.

Precipitation in the Champlain and Memphremagog valleys is appreciably lower than in most parts of New England. For the basin as a whole the average is about 36 inches, over half of which amount falls in the five months of June through October. Temperatures vary with altitude, the average being about 20° in winter and 66° in summer.

There are five important streams in the Champlain basin: Poultney River, Otter Creek, and the Winooski, Lamoille, and Missisquoi rivers. In

addition there are many smaller streams, none of which drains more than 90 square miles.

The Poultney River rises in west central Rutland County, flows northwest about 10 miles to the State Line and then twenty miles along the New York-Vermont State Line to the South Bay of Lake Champlain. The total drainage area is 235 miles of irregular agricultural land.

Otter Creek rises in northern Bennington County, flows north and slightly west a distance of over 100 miles and empties into Lake Champlain just north of Vergennes. The drainage area of Otter Creek is 943 miles of rolling-to-rugged farm and wooded country. Water surface amounts to less than 0.5% of the total area.

The Winooski River is the largest of the eastern Champlain tributaries. Rising in northeastern Washington County, on the east side of the Green Mountains, it flows southwest, then northwest through the Green Mountains to Lake Champlain, just north of Burlington, a total distance of nearly 110 miles. The drainage area of 1076 square miles includes some of the most rugged terrain in Vermont.

The Lamoille River also has its source east of the main crest of the Green Mountains, in western Caledonia County. It flows northwest and west a distance of about 90 miles to Lake Champlain near Milton. The drainage area of 710 square miles is rolling and irregular in the east, rugged in the central portion, and low and rolling near Lake Champlain. The Lamoille River, one of the steepest large rivers in New England, has a total drop of over 1200 feet.

The Missisquoi River is an international stream, crossing the Canada-Vermont line twice in its 90-mile course from western Orleans County to Lake Champlain just south of the Canadian line. The total area drained by the Missisquoi River is 885 square miles of rolling and irregular country somewhat lower than that drained by the Champlain tributaries to the south. About 260 square miles of the drainage basin are in Canada, and the remaining 625 square miles, including the principal headwater streams and the entire lower half, are in Vermont.

The principal streams in the Memphremagog basin are, from west to east, the Black, Barton and Clyde rivers, all of which enter the southern end of Lake Memphremagog. The Black River flows slightly east of north a distance of about 35 miles, and drains an area of 92 square miles. The Barton River flows almost due north, is about 25 miles long, and drains 186 square miles. The Clyde River flows northwest, has a total length of 30 miles, and drains 142 square miles. The Barton and Clyde rivers have appreciably larger proportions of water area than other Vermont streams.

The area to the east of the Memphremagog Basin, about 125 square miles of very sparsely developed country, is drained by branches of the Massawippi River, which flows into the St. Francis a short distance above the outlet of Lake Memphremagog.

Discharge records for these Vermont rivers have been obtained at numerous gaging stations by the U. S. Geological Survey, in cooperation with the state of Vermont. Detailed data for these stations may be found in Water Supply Paper - Part 4 - St. Lawrence River Basin, published by the U. S. Geological Survey.

The figures in Table III-G are summarized from unpublished records in the office of the District Engineer (U.S.G.S.) at Boston, Massachusetts, as well as from the Survey's various Water Supply Papers covering Part 4 - St. Lawrence River Basin.

Hydrographs have been drawn depicting the monthly average runoff, in cubic feet per second per square mile for:

Otter Creek at Middlebury, Vermont	(14 years)
Winooski River at Montpelier, Vermont	(15 years)
Lamoille River at Johnson, Vermont	(8 years)
Missisquoi River at Richford, Vermont	(14 years)

The mean annual discharge during the period of record at these four stations has been:

Otter Creek (Drainage Area 628 sq. mi.) 1.51 c.f.s.
Winooski River (Drainage Area 433 sq. mi.) 1.32 c.f.s.
Lamoille River (Drainage Area 335 sq. mi.) 1.64 c.f.s.
Missisquoi River (Drainage Area 479 sq. mi.) 1.90 c.f.s.

At stations on Lakes Champlain and Memphremagog are kept continuous records of the variable lake elevations.

HUMAN OCCUPANCY

Population The population of these two basins, according to the Census of 1930, was approximately 230,000, of which number 211,000 were in the Champlain Basin. The average population density for the region is 47 per square mile. Except in certain mountainous areas and a few urban centers the population is more evenly distributed than elsewhere in New England.

The only places having over 5000 population in 1930 were the following cities:

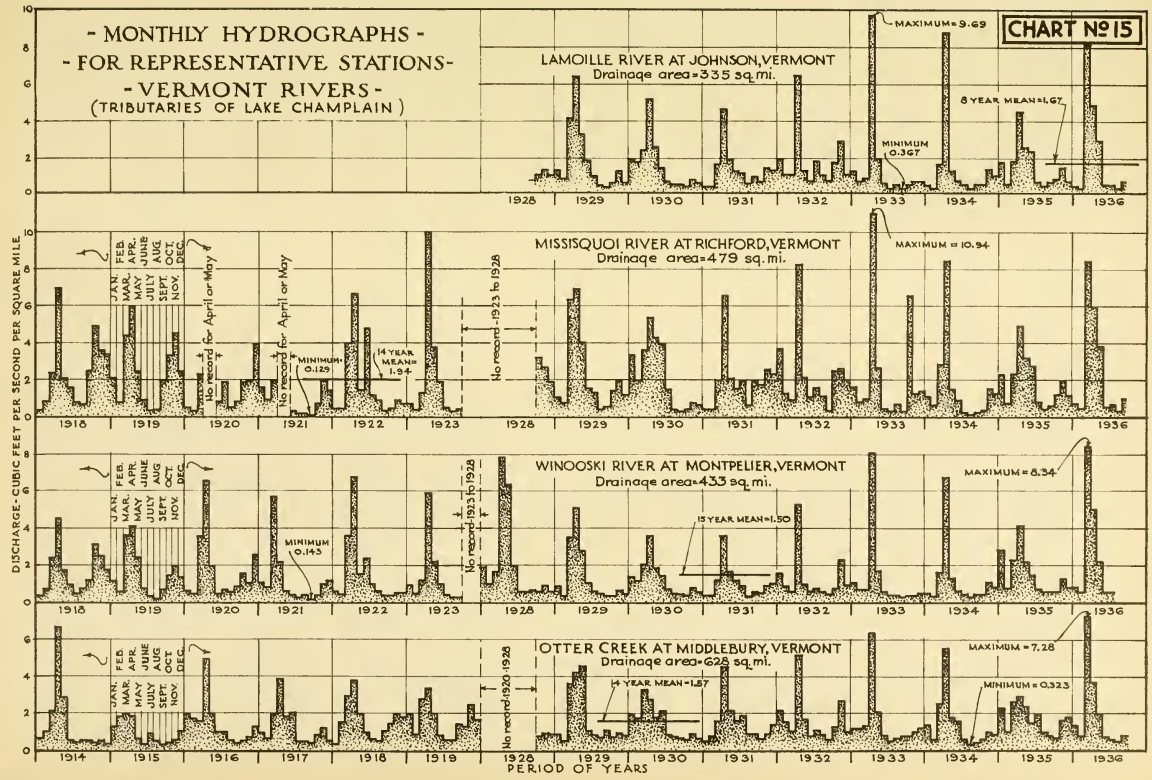
Burlington	24,789
Rutland	17,315
Barre	11,307
St. Albans	8,020
Montpelier	7,837
Winooski	5,308
Newport	5,094

Burlington, the principal city in the northern part of the region, is an important industrial, trade and educational center. Rutland, in the heart of the marble region, is the chief industrial point in the southern part of the basin. Montpelier, the state capital, and Barre, famous for granite, lie in the Winooski Valley east of the Green Mountains. All these cities are marketing centers for the surrounding country. There are in the two basins 15 towns which have between 2500 and 5000 inhabitants.

Between 1920 and 1930 the population in this region was increased by 3%, while the increase for the entire state was 2%. A similar relationship was shown between 1900 and 1930 when this section had an increase of nearly 6% and the state 4.6%. All cities of more than 5000 population showed gains between 1920 and 1930. In general, communities that gained lie in the western lowlands adjacent to Lake Champlain and in the Winooski valley in the vicinity of Montpelier and Barre. Indications are that these are the areas of future growth, due probably to industry and agriculture.

Agriculture The population is about two-thirds rural, and of the total rural about half is rural-farm. The latter proportion prevails throughout Vermont. In the Champlain Valley the principal farming activities are dairying and potato and fruit growing. Farm conditions in the western uplands are not so favorable, hence farming there is practically limited to dairying and the maple sugar industry. The value of farm products in 1930 was $41,000,000, about two-thirds of the total for the entire state. Dairy products accounted for about one-half of the total revenue, and field and orchard crops for more than one-third.

Agricultural conditions in Vermont are being studied by state agencies and efforts are being made to direct the industry along the most effective lines. Unfavorable farming and living conditions in many parts of the hill regions indicate the need for rural zoning and abandonment of unprofitable farm land. These practices will bring about better conditions in the farm life of the region and will improve the economic status of many rural communities.


- MONTHLY HYDROGRAPHS -
- FOR REPRESENTATIVE STATIONS -
- VERMONT RIVERS -
(TRIBUTARIES OF LAKE CHAMPLAIN)
CHART No 15
LAMOILLE RIVER AT JOHNSON, VERMONT
Drainage area = 335 sq. mi.
MAXIMUM = 9.69
8 YEAR MEAN = 1.67
MINIMUM 0.367
MISSISQUOI RIVER AT RICHFORD, VERMONT
Drainage area = 479 sq. mi.
MAXIMUM = 10.94
No record for April or May
MINIMUM 0.129
14 YEAR MEAN = 1.94
No record 1923 to 1928
WINOOSKI RIVER AT MONTPELIER, VERMONT
Drainage area = 433 sq. mi.
MAXIMUM = 8.34
15 YEAR MEAN = 1.50
MINIMUM 0.145
OTTER CREEK AT MIDDLEBURY, VERMONT
Drainage area = 628 sq. mi.
MAXIMUM = 7.28
14 YEAR MEAN = 1.87
MINIMUM = 0.323
No record 1920 - 1928
JAN. FEB. MAR. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.
DISCHARGE - CUBIC FEET PER SECOND PER SQUARE MILE
PERIOD OF YEARS

Industry In 1929, industries in the region employed 15,000 workers and produced manufactures valued at $80,000,000, about 56% of the total value of Vermont manufactures. In 1933, the value of manufactures had dropped to $35,000,000, and the number of wage earners to 9,000. Stone and clay products provided the largest part of manufacturing revenue; textile manufactures were second in importance, and lumber products third. In the Burlington region there are textile mills, principally wool, and wood and metal-working industries. Rutland contains small iron and steel industries, wood-working plants and railroad shops. Barre is the center of granite production, and also has shops for the manufacture of stone-working machinery.

Although industry suffered heavy losses between 1929 and 1933, it showed substantial recovery in the next two years. The U. S. Census reports an increase of 46% in the value of manufactured products between 1933 and 1935 for the state of Vermont as contrasted with an increase of 30% for all New England. This may be accounted for in part by the fact that native raw materials constitute the basis of Vermont's industries and that for several years before the depression there was a slow, steady increase in stone and clay production and in the manufacture of wood specialties. The possibilities for expansion of industries based on native materials are significant.

Mining The Champlain basin is rich in mineral resources. The principal marble quarries and finishing works are at Proctor, near Rutland; the largest quarries of monumental granite in the world are at Barre. Both types of stones abound in many parts of the region. In Poultney, south of Rutland, slate is quarried, and asbestos deposits are to be found in Lamoille County. If markets for stone products stay at their present levels, progressive development will insure future growth for the stone industries.

Lumbering This region lies in the spruce and northern hardwoods belt which extends throughout northern New England. The lumber industry, which employed in 1930 about one-fifth of the industrial workers of the region, is active in most of the upland area, and its products are diversified.

Although lumber production declined in 1930, there was a gain in the manufacture of wood products. Increased application of improved forestry practices such as are in effect in the National Forest will tend to stabilize timber production from both publicly and privately owned woodland.

Recreation Hundreds of summer homes and camps line the shores of Lake Champlain, while in the mountain regions are located many summer residences and resorts. In the forests and reservations carefully planned facilities are being developed for all phases of recreational use. Recreation is recognized as one of Vermont's most valuable assets.

The fluctuating level of Lake Champlain has a direct bearing on the recreational value of its shores. Control of this variation within more desirable limits will undoubtedly preserve and add to the basin's recreational advantages. Such control can be effected only through cooperation by Vermont, New York and Canada.

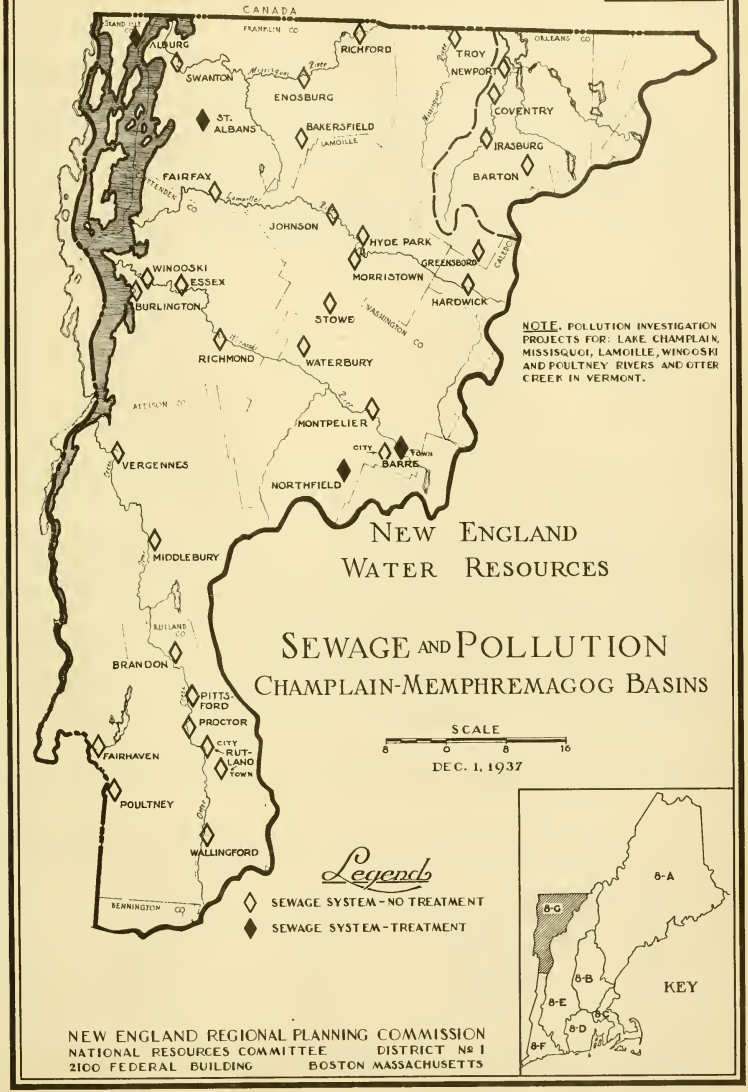
Transportation Navigation is confined to Lake Champlain, Burlington being the only port in Vermont of commercial importance. Except for maintenance

of a channel in Otter Creek, from the Lake to Vergennes, little improvement for navigation purposes has ever been made on Vermont tributaries to Lake Champlain and there is no economic justification at present for additional projects.

There is a good system of highways in the Champlain lowlands and along the principal river valleys; however, many of the secondary roads, especially in the more remote districts of the Green Mountains are relatively unimproved.

Railroad service in the basin is provided chiefly by the Rutland and Central Vermont Railroads, with lines running the entire length of the Champlain Valley and with direct connections to Montreal, Connecticut Valley points and the industrial centers of southern New England and New York State. Additional service to the Connecticut Valley is furnished by the St. Johnsbury and Lake Champlain and by the Montpelier and Wells River Railroads.

The Champlain Basin is crossed by the existing U. S. civil airways from New York through Burlington to Montreal and from Burlington to Boston. Scheduled air transport service is provided at the Burlington and Barre-Montpelier airports on the Boston-Montreal line. Regular service from Burlington to New York is desirable, as is the development of an airway south from Burlington through Rutland and the Green Mountain recreation region to Albany and New York.



NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

WATER USE AND CONTROL

Pollution The Champlain and Memphremagog tributaries are comparatively free from pollution, although there are many places where the discharge of domestic sewage and, in some cases, of industrial wastes, creates a local nuisance. All the larger municipalities of the basin have sewerage systems, but only four -- Barre town, St. Albans city, Northfield and Alburg -- have treatment plants. Several cities, notably Burlington, Barre, Rutland and Newport, cause polluted conditions which can probably be alleviated only through the installation of treatment works.

Those towns which have water-supply but no sewerage systems are:

West Rutland	3421	Cambridge	1402
Derby	2165	Berkshire	1234
Brighton	2002	Cabot	1107
Bristol	1832	Jericho	1091
Castleton	1794	Danby	1070
Milton	1663	Franklin	1001
Williamstown	1608		

In addition to these there are 11 towns of less than 1000 population which have public water supplies but no sewerage systems.

The large lakes, particularly Champlain and Memphremagog, are centers of recreational activity, and hence should be comparatively free from pollution. Conditions are not bad at present but precautionary measures should be taken lest they become so. The same general situation exists on the larger streams. Their use for recreation is great, yet their use as carriers of waste is likely to become so great that recreational activity will be jeopardized. Below such population centers as Rutland, on Otter Creek, and Montpelier-Barre, on the Winooski, fish, suffocated because pollutive matter has so reduced the amount of dissolved oxygen in the waters, either die or are driven away. Only the great amounts of fall, with consequent aeration, prevent Otter Creek and the Winooski River from becoming seriously polluted.

Other streams where pollution is so great as to menace fish life are: the Lamoille, below Hardwick; the Missisquoi, below Enosburg Falls; and the Barton, below Barton.

Water Supply The only towns of over 1000 population which do not have organized water supply systems are:

Colchester	2638	Ferrisburg	1285
St. Albans town	1691	South Burlington	1203
Highgate	1574	Newport town	1193
Sheldon	1563	Georgia	1090
Fairfield	1541	Charlotte	1089
Pawlet	1476	Hinesburg	1019
Montgomery	1386	Shelburne	1006

Practically all of the water systems are municipally owned; three-fourths have spring sources, supplemented in some cases by surface water sources.

Of the larger systems, that at Burlington has filtration and chlorination, and those at Rutland and Montpelier have chlorination. The only other systems which have treatment plants are at Proctor, Barton, and Alburg.

While most sources of supply are adequate to serve present and anticipated future demands, there are many instances where the water is not so pure as is desirable. Corrective measures needed are chlorination, filtration, or, in some cases, more careful protection of tributary watersheds. The supplies at Barre and Vergennes have, at times, dangerously high bacterial content; at Vergennes water from polluted Otter Creek is used without treatment. Here and at Milton the albuminoid ammonia content has repeatedly been so high as to indicate need for treatment.

At Rutland, Montpelier, Barre, and several smaller municipalities the water has high color, odor, turbidity and other unpleasant qualities. The water of many towns is harder than elsewhere in New England. The following systems, all with spring sources, have the hardest water:

Town	Hardness in P.P.M.
Pittsford	144
Shrewsbury	137
Calais	132
Albany	125
Greensboro	120

Flood Control The valleys of this basin are subject to excessive flooding because of their steep slopes and narrow, crooked river channels. That monetary flood losses here have not been greater is due only to the fact that there is not so much investment in real property along these rivers as on streams like the lower Connecticut, Merrimack and Blackstone. Nevertheless, a high percentage of residential, industrial and agricultural development, as well as all important lines of communication and transportation, lie in the valleys of the main streams. Hence, a damaging flood puts a stop to the normal activities of the entire basin.

The flood of November, 1927, the most serious on record in this basin, caused damages of over $20,000,000 and took at least 65 lives -- 55 on the Winooski River alone. The flood of 1936 was not so disastrous here as to the east and south; the runoffs in this latter flood were only about half so great as those nine years before. The only flood of record which may have exceeded the 1927 flood occurred in 1830, but sparsity of development was such that the losses could not compare with those suffered in either 1927 or 1936.

The 1927 flood was caused by excessive rainfall (4 to 10 inches in 2 days) on ground already saturated by previous rainy weather. Runoff reached peaks of 100 c.f.s. per square mile throughout most of the basin, and rates as high as 300 c.f.s. per square mile were recorded in some localities. Lack of either natural or artificial storage, together with lack of adequate ground cover on many of the steep hillsides, contributed to the speed of runoff, naturally great because of the steep slope of the river valleys. Damages were greatest where bridges, dams, and industrial development constricted channels.

MAP Nº 9G
CANADA
ALBURG
SWANTON
FRANKLIN
BERKSHIRE
RICHFORD
TROY (2)
NEWPORT
COVENTRY
BRIGHTON
ENOSBURG
ST ALBANS
BAKERSFIELD
FAIRFAX
WATERVILLE (3)
JOHNSON
TRASBURG
ALBANY
BARTON (2)
CRAFTSBURG
GREENSBORO
MILTON
COLCHESTER
CAMBRIDGE (2)
HYDE PARK
MORRISTOWN
WINOOSKI
ESSEX
UNDERHILL
BURLINGTON
JERICHO
STOWE
ELMORE
HARDWICK
RICHMOND (2)
WATERBURY
CABOT
CALAIS
MARSHFIELD
MONTPELIER
PLAINFIELD
BARRE TOWN
BARRE CITY
WILLIAMS TOWN
NORTHFIELD (2)
ROXBURY
VERGENNES
STARKSBORO
BRISTOL
MIDDLEBURY
BRANDON
PITTSFORD
PROCTOR
CASTLETON
RUTLAND (2)
RUTLAND TOWN
W. RUTLAND
FAIR HAVEN
SHREWSBURY
POULTNEY
WALLINGFORD (2)
DANBY
BENNINGTON CO
NEW ENGLAND WATER RESOURCES
WATER SUPPLIES
CHAMPLAIN-MEMPHREMAGOG BASINS
DEC. 1, 1937
SCALE
8 0 8 16
Legend
WELL
SPRING
SURFACE
WELL
SPRING
SURFACE
TREATED WITH DISINFECTANT
WELL
SPRING
SURFACE
TREATED MECHANICALLY
WELL
SPRING
SURFACE
MECHANICALLY TREATED AND DISINFECTED
INSIDE SYMBOL OF SUPERIMPOSED SYMBOLS INDICATES TREATMENT OF ALL.
SUGGESTED PROJECT
9A
9G
9B
9E
9C
9D
9F
KEY
NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT NO 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

Following the 1927 flood, investigations were carried on by the Army Engineers, and by an Advisory Committee of Engineers on Flood Control appointed by the Vermont Public Service Commission at the request of Governor Weeks. These investigations showed that the streams which required most consideration were the Winooski, Lamoille and Missisquoi rivers and Otter Creek. Neither the minor tributaries of Lake Champlain nor the Memphremagog tributaries were so susceptible to floods because they had larger amounts of storage and more gradual slopes.

H. K. Barrows, Consulting Engineer of the Advisory Committee, stated that "the only scheme of flood control that can be suggested as rational for Vermont is by construction and proper operation of power reservoir systems, by which the flood hazard will be reduced to a minimum." Similarly, the Army Engineers found that the amounts of money which might justifiably be spent for flood control (Winooski River $4,000,000; Lamoille River $400,000; Missisquoi River $300,000; Otter Creek $250,000) would by no means meet the cost of works necessary for such control. They did, however, recommend channel improvements on the Winooski River at an estimated cost of $200,000; on the Lamoille River, $66,000; on Otter Creek, $72,000.

Both the Consulting Engineer and the Army Engineers recommended systems of power-storage reservoirs for these 4 rivers because of the purpose such reservoirs would serve in controlling floods. These recommendations will be discussed in the following section, "Power."

In 1934 it became apparent that the construction of flood control works in Vermont would be justified by charging part of the cost to work relief. Accordingly the Army Engineers selected three sites recommended by them and by the Consulting Engineer. The sites were acquired by the state of Vermont, and construction work, estimated to cost about $6,378,000, was undertaken by units of the Civilian Conservation Corps under supervision of the Army Engineers. At the East Barre and Wrightsville sites, the ones which had been recommended for initial development by the Consulting Engineer, retarding basins, with no conservation storage, had been constructed and were in operation by the time of the 1936 flood, when they demonstrated their effectiveness in controlling all flood flows from a total drainage area of 108 square miles. The reservoir at the third site, on the Waterbury River, was developed for both flood control and conservation storage. Power rights were reserved by the power company which had controlled the site. In 1936 this reservoir was not yet ready to be put in operation, but it is now so nearly complete that it could be used to control completely the flood runoff from the 109 square miles above it if occasion demanded. In addition to the construction of these three reservoirs the reconstruction of a dam in Montpelier and the improvement of channels on the Lamoille River and Otter Creek are flood control measures taken in the Champlain Basin since the 1927 flood.

Power Water is the prime mover for about 75% of all utility power generated in this region. Again, about 75% of the 104,345 H.P. of water power installed on the tributaries of Champlain and Memphremagog is used to generate utility power.

The only plants of over 5,000 horsepower capacity are:

Site	River	Head	Cap. HP	Use
Molly's Falls	Molly's Brook (Winooski)	360	6,700	Utility
Essex Jct.	Winooski	58	6,430	"
Milton Village	Lamoille	97	6,400	"
Proctor	Otter Creek	120	6,000	Manufacturing
Sheldon Springs	Missisquoi	72	5,400	"

The following summary of all water power plants of over 100 horsepower in this area was compiled from information in the Boston office of the U. S. Geological Survey:

River	No. of Plants	Total Capacity
Missisquoi	18	12,585
Lamoille	16	18,535
Winooski	25	29,970
Otter Creek	28	35,955
Other Champlain Tributaries	5	950
Memphremagog Tributaries	4	6,350
Total	96	104,345

There is a large amount of potential power, mostly in small blocks, but the development of this power is largely contingent upon the development of storage. There is little demand for secondary power in this area, but there is a potential market for primary power, especially in the Winooski and Otter Creek basins.

The Consulting Engineer on flood control in Vermont outlined an extensive program for power and storage development on all sizable rivers in the state. The flood control storage in such a system would have been incidental, but probably adequate to prevent any severe flood damages -- flood waters were to be stored as a surcharge above spillway level and in that part of the reservoir below spillway level which happened to be, or which, through careful prediction of runoff and regulation of water levels, could be rendered empty when floods occurred.

The power benefits of the systems were to be realized in three ways: by developing power at reservoir sites, by developing new power sites, and by expanding existing power plants to take advantage of increased flows due to storage. Proposed developments were classified into priorities, 35 of the 51 suggested sites being placed in the "better" sites group, and 9 being recommended for initial development.

Pertinent data on the 51 storage developments, and all power developments

MAP Nº 10 G

NEW ENGLAND WATER RESOURCES

RECOMMENDED PROJECTS

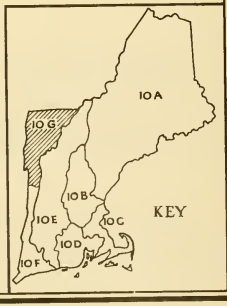
EXCEPT WATER SUPPLY AND POLLUTION PROJECTS

CHAMPLAIN-MEMPHREMAGOG BASINS

DEC. 1, 1937

SCALE

8 0 8



NEW ENGLAND REGIONAL PLANNING COMMISSION
NATIONAL RESOURCES COMMITTEE DISTRICT Nº 1
2100 FEDERAL BUILDING BOSTON MASSACHUSETTS

was summarized in the final report (1930) of the Advisory Committee of Engineers as follows:

	Missisquoi	Lamoille	Winooski	Otter Cr.	Others
Storage and Power Projects	7	12*	10*	14	8*
Storage Cap. below Spillway (A-Ft.)	158,000	224,000	332,000	275,000	127,000
Storage Cap. above Spillway (A-Ft.)	76,000	104,000	111,000	159,000	58,000
Cost of Storage (000 omitted)	$8,927	$ 9,271	$11,690	$10,196	$3,295
Power Proj. (Incl. redevel.)	8	6	6	8	4
Total Head (Feet)	805	2,096	1,911	5,192	1,092
Total Power (Horsepower)	68,400	66,400	72,500	94,400	27,300
Cost of Power (000 omitted)	$8,571	$7,694	$6,950	$9,868	$3,132
Yearly Output (Million Kwhrs)	231	244	248	305	87
Total Cost (000 omitted)	$17,498	$16,965	$18,640	$20,064	$6,427
Cost per Kwhr of Output)	0.81¢	0.74¢	0.80¢	0.71¢	0.79¢

*At one reservoir on the Lamoille, one on the Winooski, and one on the Clyde there would be no power developments.

The 9 reservoirs selected as most desirable for initial development included two each on the Missisquoi, Lamoille and Winooski rivers and Otter Creek and one on the Clyde River, as follows:

	Drainage Area	Storage Thousand Acre-ft.	Cost of Storage $1000	Head Feet	Capacity H.P.	Power Cost $1000	Storage Cost per ac-ft. per foot of head
Jay Branch	132	19.3	886	123	4400	284	10.4¢
Mud Creek	32	16.1	1185	150	1300	147	16.7¢
Great Pond	16	9.2	165	525	2100	380	1.9¢
E. Johnson	56	12.4	449	297	3600	344	5.8¢
Jail Branch	38	16.1	640	533	4500	420	5.1¢
No. Branch	70	29.3	1230	134	2000	200	11.4¢
Wallingford	96	23.0	1950	53	1500	222	19.8¢
Tinmouth	28	15.6	352	430	3500	302	2.8¢
Salem Pond	135	15.1	281	81	2600	355	7.1¢

Of the total storage costs ($7,133,000) $2,711,000, or 38%, would be charged against power benefits. On that basis the total costs of increased primary power on the five rivers concerned would be, respectively, 0.87, 0.32, 1.06, 1.29, and 0.28 cents per kilowatt-hour. The two sites selected for the Winooski River (East Barre on the Jail Branch and Wrightsville on the North Branch) were developed as retarding basins in 1935-36 and hence have no value for power storage at present.

As a result of their studies the Army Engineers concluded that power storage reservoirs on the Missisquoi, Lamoille, and Winooski rivers and on Otter Creek would provide the only economically feasible method of obtaining flood control.

As the most effective initial programs the Army Engineers selected 3 sites on the Missisquoi, 4 on the Lamoille, 7 on the Winooski, and 2 on Otter Creek. In the case of the Winooski, they recommended Federal aid to the extent of $1,000,000, but they felt that developments on the other streams could wait until power demands were sufficient to justify the expenditures needed to supplement the comparatively small amounts of cost which could be charged against local flood control benefits.

Data on the sixteen sites selected, of which all but the Huntington site were included among the "better" sites of the Vermont Advisory Committee, selections are as follows:

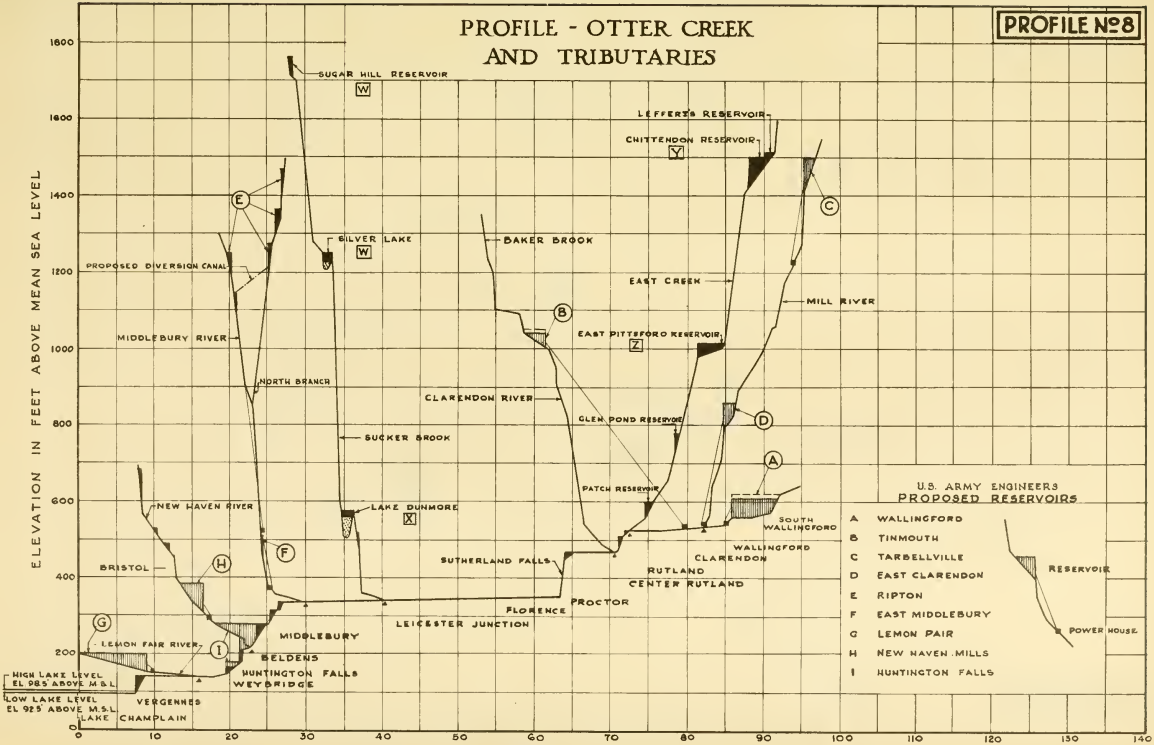
	Drainage Area	Storage Acre-ft.	Cost of Storage $1000	Head Feet	Cap. H. P.	Cost of Power $1000	Storage Cost per acre-ft. per ft-head.
Missisquoi							
Jay Branch	132	44,800	1338	142	5,700	193	6.4¢
Sheldon	117	38,600	1442	30	1,000	60	14.9¢
Tyler Branch	58	12,500	891	53	900	62	26.0¢
Lamoille							
Brown River	75	30,900	686	26	2,900	124	8.5¢
Gihon	55	10,300	729	233	5,800	626	13.1¢
Green River	17	12,500	201	65	1,450	60	1.7¢
Wild Branch	30	9,300	895	81	1,450	142	19.2¢
Winooski							
E.Montpelier	183	42,200	2,193	62	4,400	246	11.9¢
E.Barre**	38	15,300	1,004	360	6,400	581	8.9¢
S.Barre#	30	10,000	687	#	#	#	#
Wrightsville**	70	30,200	1,342	127	4,400	334	11.2¢
Moretown	125	28,700	925	84	4,100	309	8.2¢
Waterbury*	109	61,500	2,358	143	10,000	295	10.6¢
Huntington	60	20,400	1,232	220	5,800	626	15.9¢
Otter Creek							
Wallingford	96	17,150	1,845	54	2,200	226	23.5¢
Tinmouth	18	15,040	243	510	4,400	447	1.9¢

* Constructed, 1935-1937, according to modified plans.
**Constructed, 1935-1937, as retarding basin - no conservation storage or power plant.
Retarding basin -- no conservation storage or power plant.

Until conditions are favorable to the development of the power-storage sites mentioned above, it is unlikely that there will be any significant measures taken to effect flood control. The unlikelihood of any substantial increase in the power market, the uncertainty as to what the Federal Government may do by way of power development and power regulation, and the losses incident to the flooding of agricultural lands by storage reservoirs make it improbable that much construction will be undertaken in the near future.

PROFILE - OTTER CREEK AND TRIBUTARIES

PROFILE No. 8



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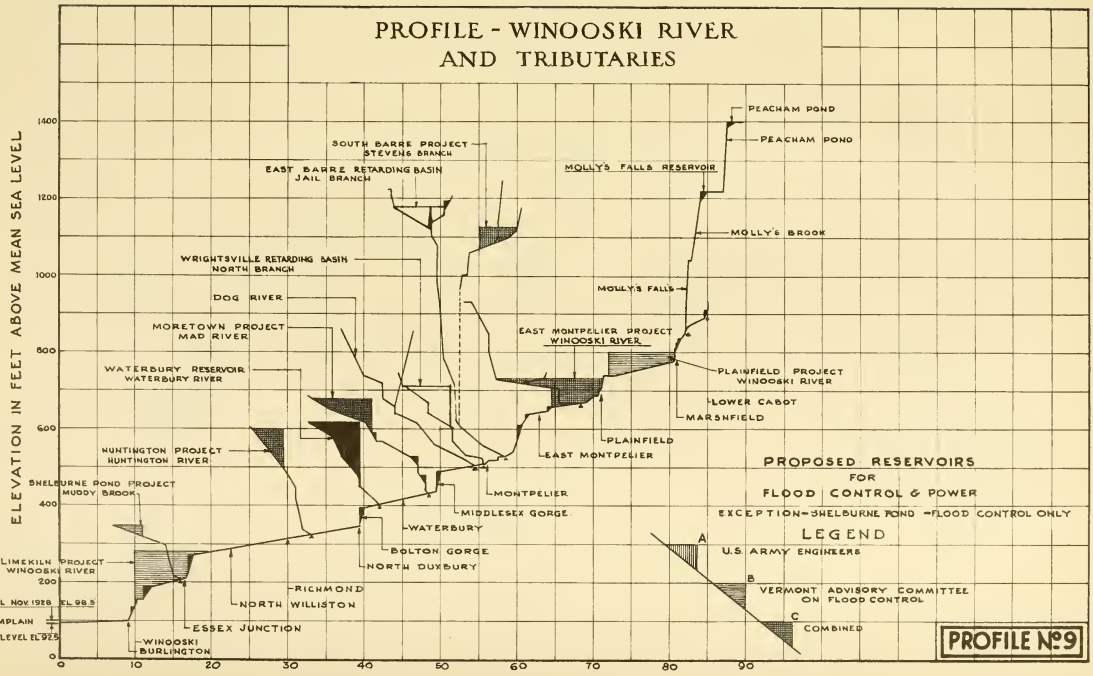
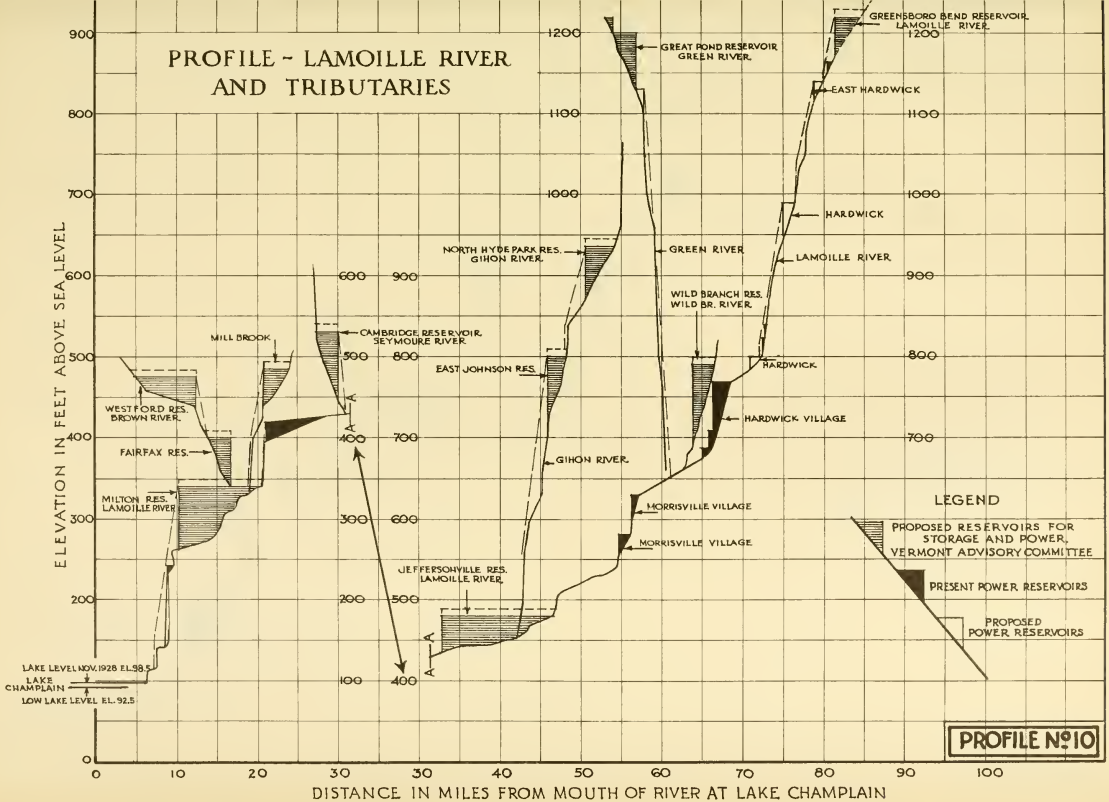
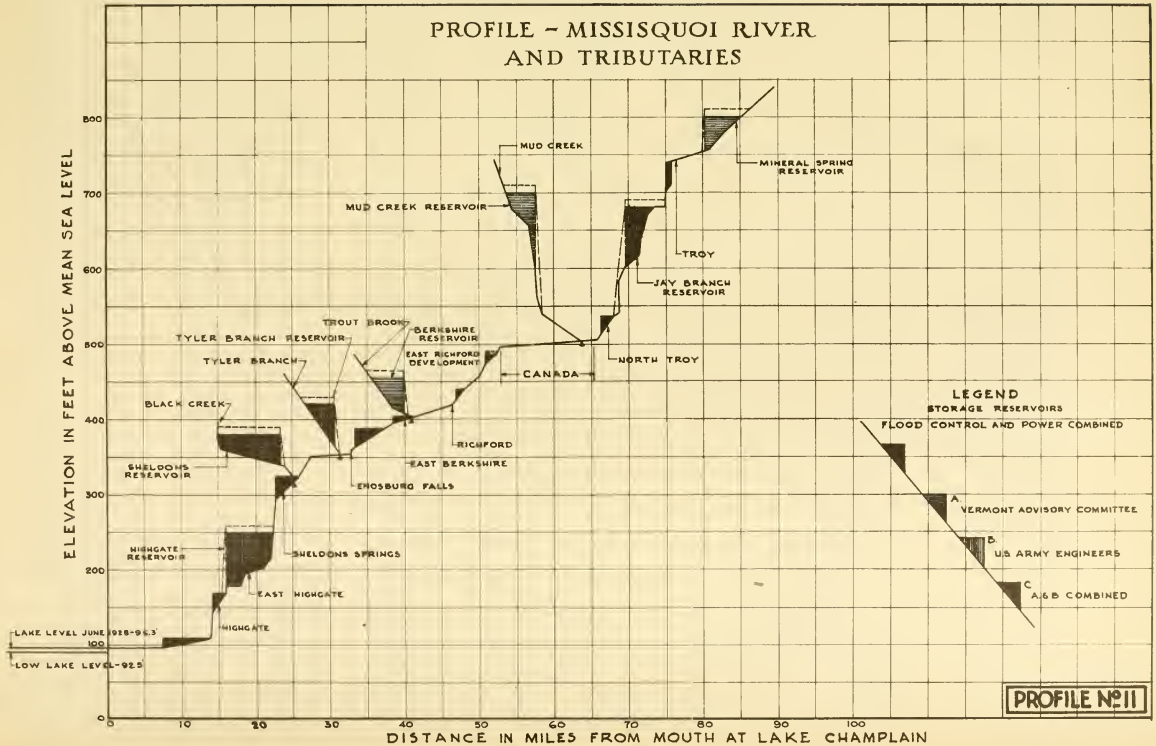

PROFILE - WINOOSKI RIVER
AND TRIBUTARIES
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DISTANCE IN MILES FROM MOUTH OF RIVER AT LAKE CHAMPLAIN
PEACHAM POND
PEACHAM POND
SOUTH BARRE PROJECT
STEVENS BRANCH
EAST BARRE RETARDING BASIN
JAIL BRANCH
MOLLY'S FALLS RESERVOIR
MOLLY'S BROOK
WRIGHTSVILLE RETARDING BASIN
NORTH BRANCH
DOG RIVER
MOLLY'S FALLS
MORETOWN PROJECT
MAD RIVER
EAST MONTPELIER PROJECT
WINOOSKI RIVER
WATERBURY RESERVOIR
WATERBURY RIVER
PLAINFIELD PROJECT
WINOOSKI RIVER
LOWER CABOT
MARSHFIELD
PLAINFIELD
HUNTINGTON PROJECT
HUNTINGTON RIVER
EAST MONTPELIER
SHELBURNE POND PROJECT
MUDDY BROOK
MONTPELIER
MIDDLESEX GORGE
WATERBURY
LIMEKILN PROJECT
WINOOSKI RIVER
BOLTON GORGE
NORTH DUXBURY
RICHMOND
LAKE LEVEL NOV 1928 EL 98.5
NORTH WILLISTON
LAKE CHAMPLAIN
ESSEX JUNCTION
LOW LAKE LEVEL EL 92.5
WINOOSKI
BURLINGTON
PROPOSED RESERVOIRS
FOR
FLOOD CONTROL & POWER
EXCEPTION-SHELBURNE POND -FLOOD CONTROL ONLY
LEGEND
A U.S. ARMY ENGINEERS
B VERMONT ADVISORY COMMITTEE ON FLOOD CONTROL
C COMBINED
PROFILE No 9


PROFILE - LAMOILLE RIVER AND TRIBUTARIES
ELEVATION IN FEET ABOVE SEA LEVEL
DISTANCE IN MILES FROM MOUTH OF RIVER AT LAKE CHAMPLAIN
LAKE LEVEL NOV. 1928 EL. 98.5
LAKE CHAMPLAIN
LOW LAKE LEVEL EL. 92.5
MILL BROOK
WESTFORD RES. BROWN RIVER.
FAIRFAX RES.
MILTON RES. LAMOILLE RIVER
CAMBRIDGE RESERVOIR SEYMOURE RIVER.
EAST JOHNSON RES.
GIHON RIVER.
NORTH HYDE PARK RES. GIHON RIVER.
JEFFERSONVILLE RES. LAMOILLE RIVER.
GREAT POND RESERVOIR GREEN RIVER.
GREEN RIVER
WILD BRANCH RES. WILD BR. RIVER.
MORRISVILLE VILLAGE
MORRISVILLE VILLAGE
GREENSBORO BEND RESERVOIR LAMOILLE RIVER.
EAST HARDWICK
HARDWICK
LAMOILLE RIVER
HARDWICK
HARDWICK VILLAGE
LEGEND
PROPOSED RESERVOIRS FOR STORAGE AND POWER, VERMONT ADVISORY COMMITTEE
PRESENT POWER RESERVOIRS
PROPOSED POWER RESERVOIRS
PROFILE No 10


PROFILE - MISSISQUOI RIVER
AND TRIBUTARIES
ELEVATION IN FEET ABOVE MEAN SEA LEVEL
DISTANCE IN MILES FROM MOUTH AT LAKE CHAMPLAIN
MUD CREEK
MINERAL SPRING RESERVOIR
MUD CREEK RESERVOIR
TROY
JAY BRANCH RESERVOIR
TROUT BROOK
BERKSHIRE RESERVOIR
TYLER BRANCH RESERVOIR
TYLER BRANCH
EAST RICHFORD DEVELOPMENT
CANADA
NORTH TROY
BLACK CREEK
RICHFORD
SHELDONS RESERVOIR
EAST BERKSHIRE
ENOSBURG FALLS
HIGHGATE RESERVOIR
SHELDONS SPRINGS
EAST HIGHGATE
HIGHGATE
LAKE LEVEL JUNE 1928-96.3
LOW LAKE LEVEL-92.5
LEGEND
STORAGE RESERVOIRS
FLOOD CONTROL AND POWER COMBINED
A. VERMONT ADVISORY COMMITTEE
B. U.S. ARMY ENGINEERS
C. A & B COMBINED
PROFILE No. 11

Drainage Large areas of swamp lands border on Lake Champlain and its southern tributary streams (Otter Creek and other Vermont streams toward the west). There are also many small swamps in the northern portion of the Champlain lowland region. In the eastern section of the drainage area the land is predominantly hilly and well-drained, although there are occasional pockets of marsh land. It is doubtful if the benefits from draining any of these swamplands would be commensurate with the cost of such drainage.

Erosion The New England portion of the Champlain basin is as seriously affected by erosion as any New England drainage area. Moderate sheet erosion (loss of 25 to 75 percent of topsoil) and occasional gullying have depleted the agricultural land over about one-third of Addison County, both on the Lake shore and in the Otter Creek valley. Similar conditions obtain in smaller areas in the Poultney, Missisquoi, Lamoille and Winooski basins. Near Georgia in Franklin County an area of approximately four square miles, the most seriously devastated in the Champlain basin, shows moderate sheet erosion accompanied by frequent gullying. Slight sheet erosion, with occasional gullies, appears in parts of Orleans and nearby counties. Overintensive grazing is the chief cause of soil erosion in these areas, and the correction of this practice, together with more careful management of crop and wood lands is needed to stop the erosive process.

Navigation Lake Champlain is connected with the Hudson River and the Great Lakes by means of the New York Barge Canal System. The Narrows of Lake Champlain carried, in 1936, 2,180 tons of terminal traffic (nearly all petroleum products) as well as 148,925 tons of cargoes in transit. The controlling depth in the Narrows is 12 feet at low lake level. Traffic in Burlington Harbor, which has a controlling depth of 10 feet, amounted, in 1936, to 148,925 tons, over 90% of which was in petroleum products. The only other port on the Vermont side of the Lake is at Vergennes, on Otter Creek, which has a controlling depth of 6 feet, but commercial shipping at this port is negligible.

Although in 1917 Congress authorized a channel 200 feet wide and 12 feet deep through the Narrows, the specified width has not been dredged. In the opinion of War Department Engineers the existing channel, 150 feet wide except at the Elbow, where the width is only 110 feet, adequately serves the present needs of commerce.

Recreation The value of recreational areas as a source of income in these basins has been proven. Public and private use is made of the Green Mountains' scenic appeal and of the lake and pond shores. A relatively scattered population with only a few points of concentration practically eliminates the need for large-scale developments to provide for local urban recreation, and renders the region eminently suitable for summer-resident occupancy. In a few localities pollution detracts from the recreational value of streams and lakes, but in most of these instances the condition could be readily corrected by inexpensive local measures.

Fishing and hunting are lucrative forms of recreational activity, and may continue to draw large numbers of vacationists to the region if adequate steps are taken to preserve the natural habitats of fish and game. Chief among these steps is the protection of marshlands along the northern shore of Lake Champlain so that their use by migratory waterfowl may continue.

TABLE III-G

SUMMARY OF STREAM FLOW RECORDS

ST. LAWRENCE TRIBUTARIES

Location of Station	Drainage Area Square Miles	Number Years of Record	Discharge in Cubic Feet per Second			
			Max. Day	Min. Day	Mean Annual	Peak Flow
Lake Champlain at Burlington, Vt.	8277	29	(Gage Heights for lake elevations only)			8.56 feet
Poultney River below Fairhaven, Vt.	187	8	5,300	4	225	6,190
Otter Creek at Center Rutland, Vt.	307	18	7,020	61	537	8,580
at Middlebury, Vt.	628	20	11,000	93	945	16,600
Winooski River at Montpelier, Vt.	433	17	15,200	17	571	57,000
at Essex Junction, Vt.	1079	8	41,600	95	1,550	113,000
Jail Branch at E. Barre, Vt.	33	3	700	7	54.5	1,260
No. Branch at Wrightsville, Vt.	69.2	3	1,620	0.5	132	2,170
Mad River near Moretown, Vt.	139	8	7,020	1.4	225	9,450
Waterbury River at Waterbury, Vt.	111	1	4,160	22	285	5,510
Dog River at Northfield, Vt.	52	15(a)	4,380	2	79.7	8,000
Lamoille River at Johnson, Vt.	335	11	11,000	27	549	13,000
near Milton, Vt.	723	7	21,700	91	1,188	23,000
Missisquoi River near No. Troy, Vt.	131	4	4,780	10	255	5,140
near Richford, Vt.	479	15	13,100	8	911	45,000
Lake Memphremagog at Newport, Vt.	658	5	(Gage heights for lake elevations only)			12.92 feet
Clyde River at Newport, Vt.	140	17	3,620	3	244	3,900

(a) This station discontinued in 1934

TABLE IV

EXPLANATORY NOTES
Concerning the table of
SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

Column 1. Town or City. Municipalities, arranged alphabetically, where available information positively indicated the existence of an organized sewerage system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 Census.

Column 3. Population Served. Best available estimate of the persons served by an organized system.

Column 4. Discharge in thousand gallons per day. The best available estimate of the volume of sewage discharged.

Column 5. Treatment. Abbreviations, noted below, indicate the type of treatment applied to the domestic wastes.

Column 6. Chief sources of Industrial Wastes. The industries which commonly pollute streams are indicated by concise reference to the type of plant, product or raw material.

Symbols

--	No information available
(P)	Partial
(s)	Summer resort
(S)	State institution
(U)	College or University
Various	Several industries present with none clearly predominant.
Milk	Refers to pasteurizing, ice cream and dairy plants.
Fert.	Fertilizer factory
Oil	Petroleum products; storage or distribution plants.
Gas	Illuminating gas manufacturing plant.
Cannery	Includes fish packing.

Im.	Imhoff Tank	A.	Aeration
Sp.	Septic Tank	Cl.	Chlorination
SF.	Sand filtration	St.	Settling
F.	Filtration	Sc.	Screening (fine)
CP.	Cesspool	Br.	Barging sludge to sea
Sl.	Sludge treatment	Sm.	Sedimentation
AcSl.	Activated sludge plant	Ir.	Irrigation

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments

TABLE IV-G

SELECTED DATA ON DOMESTIC AND INDUSTRIAL WASTES

IN MUNICIPALITIES HAVING ORGANIZED SEWER SYSTEMS

LAKE MEMPHREMAGOG BASIN

Town or City	Domestic Sewage: Population 1930	Population Served	Discharge thous. gal/day	Treatment	Industrial Wastes: Chief Sources
Barton, Vermont	3469	2650	---	none	Milk
Coventry	610	100	---	none	---
Irasburg	924	130	---	none	Milk
Newport City	5094	5000	---	none	Milk
MISSISQUOI BASIN					
Alburg, Vermont	1609	350	---	St. SF	Milk
Bakersfield	889	100	---	none	---
Enosburg	2093	1300	---	none	Milk
Troy	1898	800	---	none	Veneer
Richford	2544	2000	---	none	Plywood
St. Albans City	8020	8100	---	Sm. A. Cl.	Milk
Swanton	3433	1500	---	none	Milk
LAMOILLE BASIN					
Fairfax, Vermont	1249	40	---	none	---
Greensboro	831	125	---	none	Milk
Hardwick	2720	1700	1300	none	Stone cutting and milk
Hyde Park	1165	275	---	none	Tannery and Rendering
Johnson	1378	575	---	none	Woolens and Talc
Morristown	2939	1800	---	none	Milk and Plywood
OTTER CREEK BASIN					
Brandon, Vermont	2891	2000	---	none	Stone cutting
Middlebury	2968	2800	---	none	---
Pittsford	2332	800	---	none	---
Proctor	2596	2400	---	none	Stone cutting
Rutland City	17315	17300	---	none	---
Rutland Town	1387	350	---	none	---
Vergennes	1705	1700	---	none	Milk
Wallingford	1564	30	---	---	---

Town or City	Domestic Sewage: Population 1930	Domestic Sewage: Population Served	Domestic Sewage: Discharge thous. gal/day	Domestic Sewage: Treatment	Industrial Wastes: Chief Sources
WINOOSKI BASIN					
Barre City, Vermont	11307	11000	---	none	--
Barre Town	4280	400	---	St.Cl.(P)	--
Burlington	24789	25000	---	none	Cotton and brushes
Essex	2876	1500	---	none	Milk
Montpelier	7837	6000	---	none	Stone cutting
Northfield	3438	2400	---	F(P)	Stone cutting and Woolens
Richmond	1315	225	---	none	Milk
Stowe	1654	500	---	none	Milk
Waterbury	4045	1776	---	none	--
Winooski	5308	5200	---	none	Woolens
POULTNEY BASIN					
Fair Haven, Vermont	2614	2200	---	none	Milk and stone polishing
Poultney	3215	1570	---	none	Milk and stone polishing

EXPLANATORY NOTES
concerning tables of the ORGANIZED WATER SUPPLY SYSTEMS

Column 1. Town or city. Municipalities, arranged alphabetically, where available information indicates the existence of an organized public or semi-public water-supply system.

Column 2. Population 1930. Entire population of the civil division as reported by the 1930 census.

Column 3. Population Served. Best available estimate of the persons served by an organized system (as for the year 1936).

Column 4. Consumption in thousand gallons per day. Best available estimate of the normal daily requirement.

Column 5. Sources of supply. The type of source drawn from is indicated by symbols:- R. for Reservoir, Pond or Lake; W. for Wells, either deep or shallow; Spr. for Spring; Str. for Streams.

Column 6. Watershed area in square miles. Best available estimate of the drainage area upon which the water supply is dependent.

Column 7. Capacity in millions of gallons. Best available estimate of the quantity of water stored by, or immediately available to, the municipal supply.

Column 8. Type of Treatment. Available information concerning the methods used to improve the quality of the water served.

SYMBOLS

(2), etc. Numerals enclosed in parentheses indicate the number of separate water supply systems which serve the municipality. Where there is only one system no symbol is necessary.

(S) Includes State institution
(T) Includes Summer population served
(U) Includes College or School
(s) Provides Summer service only
(a), (b), etc. Letters enclosed in parentheses link civil divisions served by the same water source:-
In column 3 and 4 they link municipalities where available information does not give the number served in each town.
In column 5 letter indicates that the civil division imports water.
In column 6 and 7 letter indicates that the civil division exports water.
Letters link municipalities within one state and basin; cross-references between basins or states appear in footnotes.

Symbols (continued)

A.	Aeration	K.	Activated carbon
Al.	Alum	L.	Lime
AlSl.	Aluminum sulphate	MF.	Mechanical filter
Am.	Ammonia	PF.	Pressure filter
AmSl.	Ammonium sulphate	pH.	Correction of reaction
AS.	Alum - Soda Ash	RF.	Rapid filter
CC.	Corrosive correction	S.	Soda Ash
Cl.	Chlorine	SF.	Slow filter
Co.	Coagulation	Sm.	Sedimentation
CuSl.	Copper Sulphite	SoCl.	Sodium hypochlorite
F.	Filter	St.	Storage of protective significance.
IR.	Iron removal		

SOURCES OF INFORMATION

Unpublished Data, State Planning Boards
Unpublished Data, State Health Departments
Annual Reports, State Health Departments
Annual Reports, Public Utilities Commissions

TABLE V-G

ORGANIZED WATER SUPPLY SYSTEMS

LAKE MEMPHREMAGOG BASIN

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Albany, Vermont	810	150	12	Spr.	--	.005	none
Barton (2)	3,469	2,625	400	R.	--	5.67	RF.AS.Cl.48%
Brighton	2,002	1,800	--	Str.	--	.4	none
Coventry	610	100	8	Spr. & Str.	--	.006	none
Craftsbury	976	150	12	W.	--	--	none
Derby	2,165	300	--	--	--	--	--
Irasburg	924	150	--	Spr.	--	.023	none
Newport City	5,094	5,000	99	R.	--	1	none

MISSISQUOI BASIN

Alburg, Vermont	1,609	525	20	R.	--	.15	Cl.
Bakersfield	889	300	6	Spr.	--	.03	none
Berkshire	1,234	260	--	Spr. & Str.	--	--	none
Enosburg	2,093	1,200	150	Spr.	2.5	9.25	none
Franklin	1,001	140	14	Spr.	--	--	none
Richford	2,544	2,000	400	Str.	--	4.5	none
St. Albans City	8,020	8,100	1,500	Spr.	--	507	none
Swanton	3,433	1,560	--	R.	--	.5	none
Troy(2)	1,898	950	95	Str.	--	.33	none

LAMOILLE BASIN

Cambridge, Vt.(2)	1,402	850	70	Spr.	--	650.01	none
Elmore	382	30	1	Spr.	--	--	none
Fairfax	1,249	300	18	Spr.	--	.5	none
Greensboro	831(T)	450	29	Spr.	--	.2	none
Hardwick	2,720	1,700	170	Spr.	--	1	none
Hyde Park	1,165	325	47	Spr.	--	.3	none

LAMOILLE BASIN (Continued)

Town or City	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Jericho, Vt.	1,091	250	15	Spr.	--	.06	none
Johnson	1,378	600	60	Str.	--	.1	none
Milton	1,663	700	12	R.	--	.8	none
Morristown	2,939	1,800	190	Spr.	--	.45	none
Underhill	781	200	15	Spr.	.4	.03	none
Waterville (3)	370	105	--	Spr.	--	--	none

WINOOSKI BASIN

Barre City, Vt.	11,307	8,000	800	Spr. & Str.	17(a)	52.4(a)	none
Barre Town (3)	4,280	530	40	Spr. Str. & (a)	--	.54	none
Burlington	24,789	26,000	1,532	R.	--	7.2	SF.Al.Cl.
Cabot	1,107	200	14	Spr.	.3	.03	none
Colchester (Ft. Ethan Allen)	--	1,400	200	W.	--	.15	none
Calais	811	60	5	Spr.	--	.003	none
Essex	2,876	1,500	150	Spr.	1.5	7.5	none
Marshfield	872	200	15	Spr.	--	.004	none
Montpelier	7,837	6,000	2,600	R.	13	250	Cl.
Northfield (2)	3,438	1,725	119	Spr.	.9	.753	none
Plainfield	766	425	18	Spr.	2.	.005	none
Richmond (2)	1,315	750	44	Spr.	--	.022	none
Roxbury	594	70	7	Str.	--	.036	none
Stowe	1,654	600	45	Spr.	--	2.	none
Waterbury	4,045	3,000(S)	290	Spr. & Str.	2.	.5	none
Williamstown (2)	1,608	300	24	Spr.	--	.028	none
Winooski	5,308	5,200	278	Spr. & W.	--	--	none

OTTER CREEK BASIN

Town or city	Population 1930	Population Served	Consumption thous. gal/day	Sources of supply	Watershed area sq.mi.	Capacity mil/gal.	Type of treatment
Brandon, Vermont	2,891	2,000	180	R. & Str.	--	.5	none
Bristol	1,832	1,100	88	Spr.	--	10.3	none
Danby	1,070	200	80	Spr.	--	.1	none
Middlebury	2,968	3,000 (U)	300	Spr.	--	1.	none
Pittsford	2,332	1,750	31½	Spr.	--	.2	none
Proctor	2,596	2,400	350	Spr. & Str.	10.	--	SF.
Rutland City	17,315	17,300	2,993	Spr.	25.	5.	Cl.
Rutland Town	1,387	400	30	Spr.	--	.06	none
Shrewsbury	540	75	5	Spr.	--	.006	none
Starksboro	687	100	10	Spr.	--	.008	none
Vergennes	1,705	1,700	500	Spr.	1.	50.	none
Wallingford (2)	1,564	1,179	110	Spr.	2.3	.036	none
West Rutland	3,421	1,700	150	Str.	--	16.	none

POULTNEY BASIN

Castleton, Vermont	1,794	400	30	Spr. & Str.	4.	4.	none
Fair Haven	2,614	2,200	225	Spr. & Str.	.4	175.	none
Poultney	3,215	1,560	160	Spr. & Str.	.2	--	none

TABLE - VI-G

EXISTING WATER POWER - ST. LAWRENCE TRIBUTARIES

RIVER	NO. OF PLANTS IN Vermont	CAPACITY OF PLANTS OF over 10,000 HP.	1,000 to 9,990 HP.	under 1,000 HP.	CAPACITY USED FOR Utility	Mfg.	TOTAL CAPACITY Horse-power
CHAMPLAIN TRIBUTARIES	92	0	82,075	15,920	70,615	27,380	97,995
Missisquoi	18	0	7,900	4,685	2,990	9,595	12,585
Lamoille	16	0	16,395	2,140	17,515	1,020	18,535
Winooski	9	0	18,980	1,700	19,240	1,440	20,680
North Branch	4	0	0	640	0	640	640
Dog	4	0	0	590	0	590	590
Mad	3	0	0	990	670	320	990
Waterbury	3*	0	0	270	0	270	270*
Others	2	0	6,700	100	6,700	100	6,800
Otter Creek	16	0	15,300	2,285	5,450	12,135	17,585
East Creek	4	0	11,300	650	11,950	0	11,950
New Haven	4	0	0	700	250	450	700
Others	4	0	5,500	220	5,500	220	5,720
Castleton(Poultney)	3	0	0	650	350	300	650
Others	2	0	0	300	0	300	300
MEMPHREMAGOG TRIBUTARIES	4	0	5,700	650	6,230	120	6,350
Clyde	4	0	5,700	650	6,230	120	6,350
GRAND TOTAL	96	0	87,775	16,570	76,845	27,500	104,345

* One site for which no data available.

TABLE VII-G: EXISTING STORAGE

ST. LAWRENCE TRIBUTARIES

	Drainage Area Sq.Mi.	Water Surface Sq.Mi.	Storage Capacity Acre-feet	Storage Equivalent Inches of Runoff
Memphremagog Tributaries				
Seymour Lake and Echo Pond	24	--	8,000	6.3
Estimated Total	450			--
Missisquoi River				
Estimated Total	855	--	Negligible	--
Lamoille River				
Estimated Total	742		5,000	.12
Winooski River				
Mollys Falls Reservoir	23	--	9,200	7.5
East Barre Reservoir	38	--	12,000	6.0
Wrightsville Reservoir	70	--	20,500	5.5
Waterbury Reservoir	109	--	61,500	10.6
Estimated Total	1,076		105,000	1.8
Otter Creek				
Chittenden Reservoir	16	--	19,500	--
East Pittsford Reservoir	25	--	3,440	20.6
Silver Lake	11	--	1,840	--
Lake Dunmore	21	--	5,050	6.2
Estimated Total	936		30,000	0.6
Poultney River				
Bomoseen Lake	39	3.7	1,150	0.6

NOTE: Storage equivalent, in inches of runoff, is computed on a basis of all storage above point in question.

SOURCES OF INFORMATION

GENERAL SOURCES OF INFORMATION

The sources of information listed below apply, in general, to all drainage basins in New England. Additional sources studied in connection with individual basins are listed by basins.

Surface Water Supply of the United States
Part I, North Atlantic Slope Drainage Basin
U. S. Geological Survey Water Supply Papers (Issued annually)

New England Topographic Quadrangles
U. S. Geological Survey.

The New England Flood of November 1927
U. S. G. S. Water Supply Paper #636-C (H. B. Kinnison)

Floods in the United States
U. S. G. S. Water Supply Paper #771, 1936

Studies of Relations of Rainfall and Runoff in the United States
U. S. G. S. Water Supply Paper #772, 1936.

Annual Reports of Chief of Engineers -- U. S. Army

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74th Congress - Senate Committee on Commerce, Report #893

List of Bridges over the Navigable Waters of the United States
U. S. Army - Chief of Engineers - 1936

Flood Control Act of 1936
74th Congress, Public Document #733

Annual Report of the National Forest Reservation Commission
74th Congress - Senate Document #144

Fifteenth Census of the United States - 1930
U. S. Dept. of Commerce - Bureau of the Census

U. S. Census of Agriculture - 1930 and 1935
U. S. Dept. of Commerce - Bureau of the Census

Biennial Census of Manufactures
U. S. Dept. of Commerce - Bureau of the Census

Statistical Abstract of the United States - 1935
U. S. Dept. of Commerce - Bureau of Foreign and Domestic Commerce

Commercial Structure of New England
U. S. Dept. of Commerce - Bureau of Foreign and Domestic Commerce - 1929

Industrial Structure of New England
U. S. Dept. of Commerce - Bureau of Foreign and Domestic Commerce - 1930

Reconnaissance Erosion Surveys (with maps) - 1935
U. S. Dept. of Agriculture - Soil Erosion Service

Annual Reports of the Weather Bureau
U. S. Dept. of Agriculture

Annual Reports of the Federal Power Commission

Special Data Relating to the New England Area
Interim Report - Power Series #1
National Power Survey - Federal Power Commission

North Atlantic District Report upon Water Resources
National Resources Board - H. K. Barrows - 1934

Forests and Floods in New Hampshire
New England Regional Planning Commission - Publication #47 - 1936
H. I. Baldwin and C. F. Brooks

Bills introduced into Congress and the State Legislatures relative to Interstate Compacts

Various articles in the Engineering News Record and the Journal of the New England Water Works Association

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